



FOREST SERVICE WATERSHED CONDITION CLASSIFICATION TECHNICAL GUIDE

“Ultimately, our success at the Forest Service will be measured in terms of watershed health on those 193 million acres of national forests and grasslands.”

U.S. Forest Service Chief, Tom Tidwell, April 29, 2010

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October 25, 2010

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Watershed Classification and Assessment Tracking Tool (WCATT) User Guide

Brian Sanborn

National Resource Information System

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Introduction

The U.S. Department of Agriculture Strategic Plan for FY 2010-2015 targets the restoration of watershed and forest health as a core management objective of the National Forests and Grasslands. To achieve this goal the Forest Service (FS) is directed to restore degraded watersheds by strategically focusing investments in watershed improvement projects and conservation practices at landscape and watershed scales.

The Office of Management and Budget (OMB) in a 2006 review of the FS Watershed Program concluded that the FS lacks a nationally consistent approach to prioritize watersheds for improvement (U.S. OMB 2006). They also noted that current FS direction for tracking watershed condition class (FSM 2521) is vague, open to varied interpretation and insufficient to consistently evaluate watershed condition or track how condition changes over time. To address these issues, a National Watershed Condition Team was formed and tasked with the development of a nationally consistent, science-based approach to classify the condition of all National Forest System (NFS) watersheds and to develop performance-based outcome measures for watershed restoration. The team evaluated alternative approaches for classifying watersheds (USDA Forest Service 2007) and developed the watershed condition classification (WCC) system described in this technical guide.

The watershed classification approach was designed to classify the condition of all NFS watersheds, be quantitative to the extent feasible, rely on GIS technology, be cost-effective, implementable within existing budgets, and to include resource areas and activities that have a significant influence on watershed condition. National Forests are required to revise the classification on an annual basis and the information will be used as an outcome-based performance measure of progress toward improving watershed condition on NFS lands. In order to demonstrate improvement in condition class activities need to be tracked at the smallest feasible watershed unit, the 6th level Hydrologic Unit (typically 10,000 to 40,000 acres in size).

The WCC system is a National Forest based reconnaissance-level evaluation of watershed condition achievable within existing budgets and staffing that can be aggregated for a national assessment of watershed condition. The WCC offers a systematic, flexible means of classifying watersheds based on a core set of national watershed condition indicators. It necessarily relies on professional judgment exercised by Forest interdisciplinary teams, GIS data and national databases to the extent they are available and written rule sets and criteria for indicators that describe proper function, functioning-at-risk, and impaired conditions. The classification relies on Washington Office and Regional Office oversight to provide for flexibility and consistency in application among National Forests. The system is a first approximation of watershed condition and will need to be revised and refined over time. The expectation is that the individual resource indicators will be improved, refined, and that databases and map products will be developed to assist with future classifications. One of the desired outcomes is that national leadership will use the watershed condition classification

information to establish priorities, evaluate program performance, and communicate watershed restoration successes to interested stakeholders and Congress.

Objectives of this Guide

The watershed condition policy goal of the FS is “to protect National Forest System watersheds by implementing practices designed to maintain or improve watershed condition, which is the foundation for sustaining ecosystems and the production of renewable natural resources, values, and benefits” (FSM 2520). This policy was re-emphasized by USDA Secretary of Agriculture Vilsack in his “Vision for the Forest Service” when he stated that achieving restoration of watershed and forest health would be the primary management objective of the USDA Forest Service (USDA 2010). This “Watershed Condition Classification Technical Guide” helps to implement this policy objective by:

- Establishing a systematic process for determining Watershed Condition Class that can be applied consistently by all National Forests,
- Improving FS reporting and tracking of watershed condition, and
- Strengthening the effectiveness of the FS to maintain and restore the productivity and resilience of watersheds and their associated aquatic systems on NFS lands.

Defining Watershed Condition

We define **watershed condition** as the state of the physical and biological characteristics and processes within a watershed that affect the hydrologic and soil functions supporting aquatic ecosystems. Watershed condition reflects a range of variability from natural pristine (properly functioning) to degraded (severely altered state or impaired).

Watersheds in properly functioning condition have terrestrial, riparian, and aquatic ecosystems that capture, store, and release water, sediment, wood, and nutrients within their range of natural variability for these processes. Properly functioning watershed conditions create and sustain functional terrestrial, riparian, aquatic, and wetland habitats that are capable of supporting diverse populations of native aquatic- and riparian-dependent species. In general, the greater the departure from the natural pristine state, the more impaired the watershed condition is likely to be. Properly functioning watersheds are commonly referred to as healthy watersheds.

Properly functioning, healthy watersheds have five important characteristics (Williams et al 1997):

1. They provide for high biotic integrity; habitat that supports adaptive animal and plant communities that reflect natural processes.
2. They are resilient and recover rapidly from natural and human disturbances.
3. They exhibit a high degree of connectivity along the stream, laterally across the floodplain and valley bottom, and vertically between surface and subsurface flows.

4. They provide important ecosystem services such as high quality water, recharge of streams and aquifers, the maintenance of riparian communities, and moderation of climate variability and change.
5. They maintain long-term soil productivity.

Watershed condition classification is the process of describing watershed condition in terms of discrete categories (or classes) that reflect the level of watershed health or integrity. In our usage, we consider watershed health and integrity to be conceptually the same (Regier 1993). Watersheds with high integrity are in an unimpaired condition in which ecosystems show little or no influence from human actions (Lackey 2001).

The Forest Service Manual (FSM) uses three classes to describe watershed condition (USDA Forest Service 2004, FSM 2521.1).

- Class 1 watersheds exhibit high geomorphic, hydrologic, and biotic integrity relative to their natural potential condition.
- Class 2 watersheds exhibit moderate geomorphic, hydrologic, and biotic integrity relative to their natural potential condition.
- Class 3 watersheds exhibit low geomorphic, hydrologic, and biotic integrity relative to their natural potential condition.

The FSM classification defines watershed condition in terms of “geomorphic, hydrologic and biotic integrity” relative to “potential natural condition”. In this context, integrity relates directly to functionality. Geomorphic functionality or integrity can be defined in terms of attributes such as slope stability, soil erosion, channel morphology and other upslope, riparian and aquatic habitat characteristics. Hydrologic functionality or integrity relates primarily to flow, sediment and water quality attributes. Biological functionality or integrity is defined by the characteristics that influence the diversity and abundance of aquatic species, vegetation, and soil productivity. In each case, integrity must be evaluated in the context of the natural disturbance regime, geoclimatic setting and other important factors within the context of a watershed. The definition encompasses both aquatic and terrestrial components because water quality and aquatic habitat are inseparably related to the integrity, and therefore the functionality, of upland and riparian areas within a watershed.

Within this context, the three watershed condition classes are directly related to the degree or level of watershed functionality or integrity: These three Classes relate directly to watershed functionality, and therefore watershed condition, as:

- Class 1 = Functioning Properly;
- Class 2 = Functioning at Risk; and
- Class 3 = Impaired Function.

In this guide we characterize a watershed in good condition as one that is functioning in a manner similar to natural wildland conditions (Karr and Chu 1999, Lackey 2001). A watershed is considered to be in properly functioning condition if the physical attributes are adequate to maintain or improve biological integrity. This implies that a Class 1

watershed in properly functioning condition has minimal adverse human impact on natural physical or biological processes and is resilient and able to recover to a previous condition when disturbed by large natural disturbances or land management activities (Yount and Neimi 1990). By contrast, a Class 3 watershed has impaired function because some threshold has been exceeded. Significant changes to the factors that caused the degraded state are commonly needed to restore the watershed to a condition that sustains physical, hydrological and biological integrity.

Defining specific classes for watershed condition is obviously subjective and problematic for several reasons. The first is that watershed condition is not directly observable (Suter 1993). There are no distinct lines in nature that separate properly functioning from impaired condition and every classification scheme is arbitrary to some extent. Another challenge is that watershed condition is a mental construct that has numerous definitions and interpretations and many different definitions of watershed condition are found in the scientific literature (Lackey 2001). A third challenge is that the attributes that reflect the state of a watershed are continually changing as a result of natural disturbances (e.g., wildfire, landslides, floods, insects and disease), natural variability of ecological processes (e.g., flows and cycles of energy, nutrients, and water), climate variability and change, and human modifications to watersheds.

Watershed Condition and Ecological Restoration

The most effective way to approach complex ecological issues is to consider them at the watershed level, where the fundamental connection among all components of the landscape is the network of streams that define the basin (Reid et al. 1996, Williams et al. 1997, National Research Council 1999, Sedell et al. 2000, Newbold 2002, Ogg and Keith 2002, Heller 2004, Smith et al. 2005). Watersheds are also readily recognized by local communities and resonate with much of the public as a logical way to address resource management issues. Watersheds are easily identified on maps and on the ground and their boundaries do not change much over time (Reid et al. 1996).

Watersheds are integral parts of broader ecosystems and can be viewed and evaluated at a variety of spatial scales. Because watersheds are spatially located landscape features that have been uniformly mapped for the entire United States at multiple scales, they are ideal for tracking accomplishments both in terms of outputs (acres treated on the ground) and outcomes (improvement in watershed condition class). Reporting accomplishments and outcomes by each watershed's unique hydrologic unit code (HUC) avoids double counting. Watershed condition class integrates the effect of all activities within a watershed; therefore, the approach provides an ideal mechanism for interpreting the cumulative effect over time of a multitude of management actions on hydrologic and soil function. Finally, many hydrologic and aquatic restoration issues can only be properly addressed within the confines of watershed boundaries. Watersheds provide one basis for developing restoration plans and priorities that can treat a multitude of resource problems in a structured, comprehensive manner.

However, some terrestrial ecological restoration issues are poorly addressed in a watershed context. Ecological restoration issues dealing with vegetation and wildlife species composition, structure, pattern, and diversity may not affect hydrologic and soil functions and are best evaluated using ecological stratifications such as Bailey ecoregions (Bailey 1995). Consequently, we view watershed condition, watershed health, and watershed restoration to be a subset of ecological condition, ecological health, and ecological restoration.

In summary, ecological restoration focuses on the composition, structure, pattern, and ecological processes necessary to make terrestrial and aquatic ecosystems sustainable, resilient, and healthy under current and future conditions. This includes watershed condition and health. Watershed condition assessment places specific emphasis on the physical and biological characteristics and processes affecting hydrologic and soil functions that support aquatic ecosystems. Therefore, in this watershed classification system primary emphasis is placed on indicators that directly or indirectly impact soil and hydrologic and associated riparian and aquatic ecosystems.

Watershed Condition Indicators

The watershed condition classification system described in this Technical Guide uses twelve (12) *indicators* comprised of *attributes* related to watershed processes. The indicators and their attributes are surrogate variables representing the underlying ecological functions and processes that affect soil and hydrologic function. For the majority of the indicators, the FS can take direct action, or cause actions to be taken by others that can contribute to maintaining or improving watershed condition (i.e. functionality). This provides for a direct linkage between the classification system and management or improvement activities the FS conducts on the ground. Because of this linkage, when a sufficient number of properly designed and implemented restoration and/or management actions occur within a watershed, the outcome can be expressed as a change in condition class and the information used for performance accountability purposes. Management activities that effect the watershed condition class are not limited to soil and water improvement activities, but include a broad array of resource program areas from hazardous fuel treatments, invasive species eradication, abandoned mine restoration, riparian area treatments, aquatic organism passage improvement, road maintenance and obliteration, and others. To achieve a change in watershed condition class will in most cases require changes within a watershed that are significant in their scope and include treatments from multiple resource areas. Sound management or improvement to management practices can often be as effective as implementing restoration projects and must not be overlooked. In order to demonstrate improvement in condition class activities will need to be tracked at the smallest feasible watershed unit, the 6th level HUC (typically 10,000 to 40,000 acres in size)¹

¹ In the context of this classification system, the term “watershed” and “hydrologic unit” are used synonymously. However, hydrologic units are truly only synonymous with the classic watershed definition when their boundaries include all the source area contributing surface water to a single defined outlet point. For the intended uses of this reconnaissance

The suite of watershed condition indicators includes:

1. Water Quality,
2. Water Quantity,
3. Aquatic Habitat,
4. Aquatic Biota,
5. Riparian/Wetland Vegetation,
6. Roads and Trails,
7. Soils,
8. Fire Regime or Wildfire,
9. Forest Cover,
10. Rangeland Vegetation,
11. Terrestrial Invasive Species, and
12. Forest Health.

level assessment, this distinction is relatively unimportant.

The Watershed Condition Model

The basic model used in this classification system provides a Forest-wide, reconnaissance-level evaluation of watershed condition. It offers a systematic, flexible means of classifying and comparing watersheds based on a core set of national watershed condition indicators. The indicators are grouped according to four major **process categories**: (1) aquatic physical; (2) aquatic biological; (3) terrestrial physical; and (4) terrestrial biological. These categories represent terrestrial, riparian and aquatic ecosystem processes or mechanisms by which management actions can affect the condition of watersheds and associated resources.

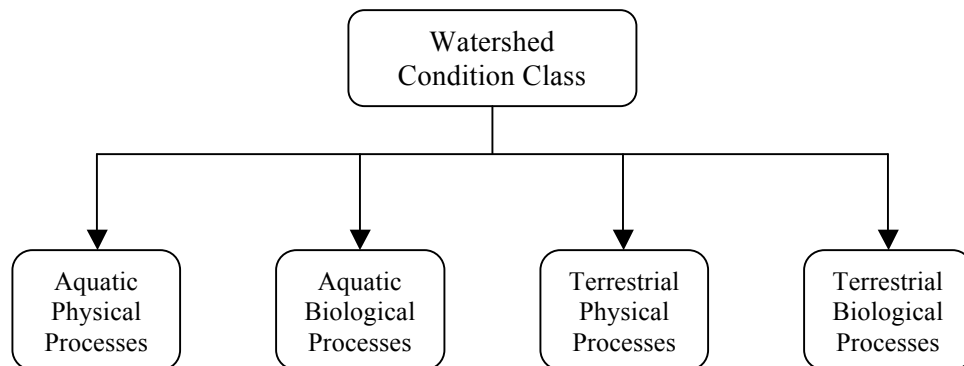


Figure 1. The Basic Watershed Condition Model

We will use a simple score card approach to assess Watershed Condition Class. Each of the four **process categories** is represented by a set of indicators (Figure 2, Table 1). Each indicator is evaluated using a defined set of *attributes*. For example, the Aquatic Physical process category contains an indicator for *Aquatic Habitat Condition*. Aquatic habitat condition is evaluated using three attributes: (1) Habitat fragmentation, (2) Large woody debris, and (3) Channel shape and function. Indicators have as few as one attribute or as many as four attributes. We designed the classification to be as simple as possible based on the “80-20 Rule” which states that commonly 80% of effects come from 20% of the causes. We also wanted to be responsive to Forest requests to keep the assessment compatible with the subjective nature of many of the evaluations. We therefore constrained the number of attributes and consequently the amount of data that Forests will need to deal with during the classification process.

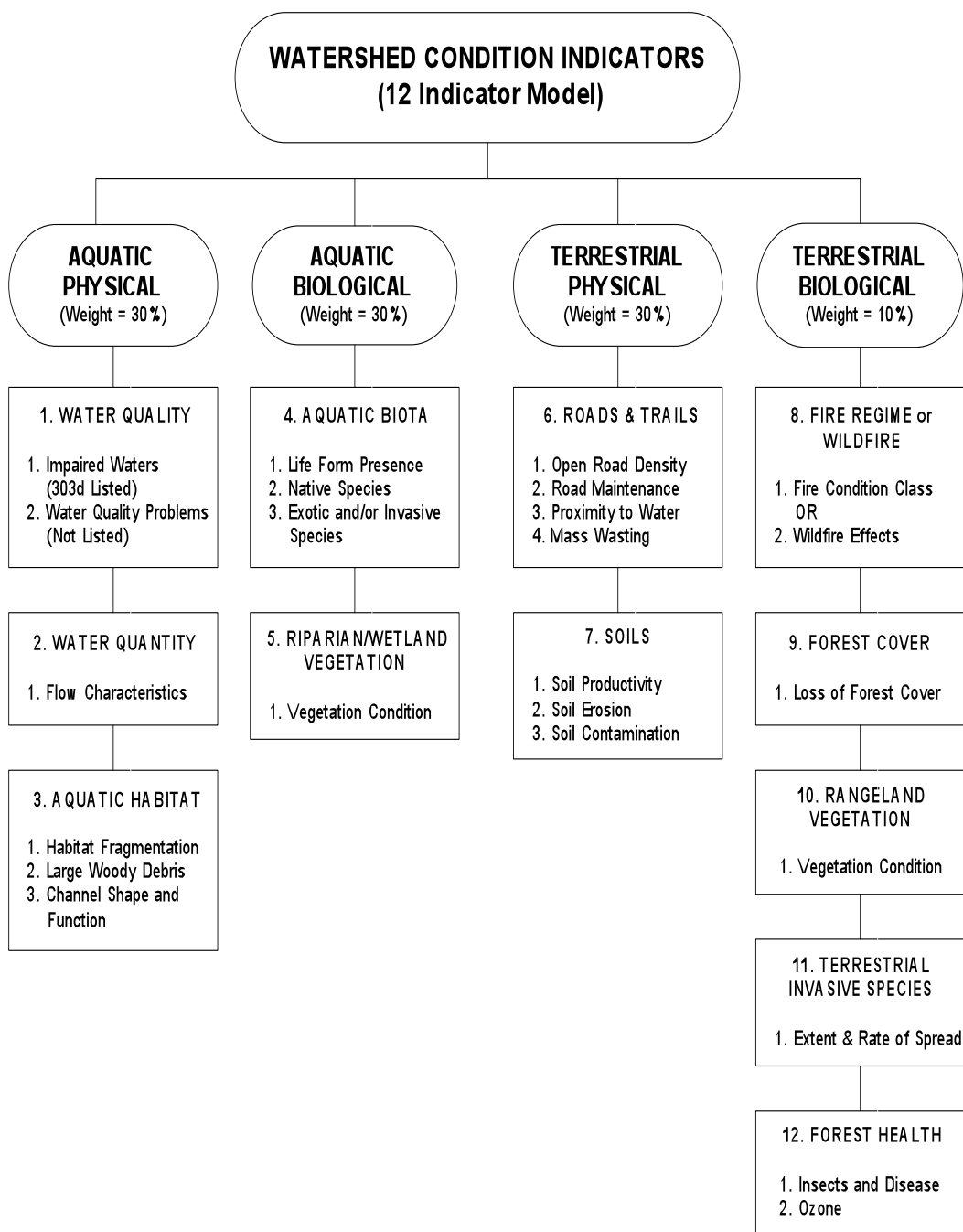


Figure 3. Core National Watershed Condition Indicators.

AQUATIC PHYSICAL INDICATORS	
1. Water Quality	This indicator addresses the expressed alteration of physical, chemical, and biological components of water quality.
2. Water Quantity	This indicator addresses changes to the natural flow regime with respect to the magnitude, duration, or timing of the natural streamflow hydrograph.
3 Aquatic Habitat	This indicator addresses aquatic habitat condition with respect to habitat fragmentation, large woody debris, and channel shape and function.
AQUATIC BIOLOGICAL INDICATORS	
4. Aquatic Biota	This indicator addresses the distribution, structure, and density of native and introduced aquatic fauna.
5. Riparian/Wetland Vegetation	This indicator addresses the function and condition of riparian vegetation along streams, water bodies, and wetlands.
TERRESTRIAL PHYSICAL INDICATORS	
6. Roads and Trails	This indicator addresses changes to the hydrologic and sediment regimes due to the density, location, distribution, and maintenance of the road and trail network.
7. Soils	This indicator addresses alteration to natural soil condition, including productivity, erosion, and chemical contamination.
TERRESTRIAL BIOLOGICAL INDICATORS	
8. Fire Regime or Wildfire	This indicator addresses the potential for altered hydrologic and sediment regimes due to departures from historical ranges of variability in vegetation, fuel composition, fire frequency, fire severity, and fire pattern.
9. Forest Cover	This indicator addresses the potential for altered hydrologic and sediment regimes due to the loss of forest cover on forest lands.
10 Rangeland Vegetation	This indicator addresses impacts to soil and water relative to the vegetative health of rangelands.
11. Terrestrial Invasive Species	This indicator addresses potential impacts to soil, vegetation, and water resources due to terrestrial invasive species (including vertebrates, invertebrates, and plants).
12. Forest Health	This indicator addresses forest mortality impacts to hydrologic and soil function due to major invasive and native forest pest insect and disease outbreaks and air pollution.

Table 1. Description of the 12 national core watershed condition indicators. See Appendix A for the complete rule set.

We recognize from a scientific perspective that this watershed conditions model with many indicators will have problems with auto correlation. However, because of the management need to show linkages between activities on the ground and improvement in watershed condition for performance accountability we chose to include a comprehensive suite of indicators that represents the full scope of FS management activities and program areas. For example, road condition and stream habitat condition may be highly correlated, however, eliminating one as an indicator, such as stream habitat condition, would then preclude having a feedback mechanism for taking credit for watershed condition improvements derived from stream habitat improvement work. This approach favors management performance tracking and accountability at the expense of a more scientifically correct classification model.

Types of Indicators

We define indicators as simple quantifiable or qualitatively determined measures of the condition and dynamics of broader, more complex attributes of ecosystem health. Indicators are used because complex ecosystem attributes are difficult, inconvenient, or too expensive to measure. Indicators are therefore surrogates representing the underlying ecological functions that maintain watershed functionality and condition. The basic watershed condition model strives to use indicators that represent existing, on-the-ground alterations of watershed conditions. Indicators will be refined over time as better data and analysis tools become available.

The indicators include three basic types of attributes:

- *Numeric attributes* have associated numeric values (e.g., road density <1 mile/mi²). Quantitative attributes are simple to use, but need to be properly interpreted and appropriate for the geographical setting of the watershed.
- *Descriptive attributes* are qualitative variables subject to some degree of interpretation by users (e.g., “Native mid to late seral vegetation appropriate to the sites potential dominates the plant communities and is vigorous, healthy and diverse in age, structure, cover and composition on >80% of the riparian/wetland areas in the watershed.”). These semi-quantitative attributes are typically used when reliable numeric indicators or thresholds are lacking or where quantitative data is either unavailable or too expensive to obtain for entire watersheds.
- *Map-derived attributes* are produced by teams of experts that synthesize extensive data to create interpreted map products (e.g., fire regime condition classes). Map products are generally of high quality and objective if applied at the appropriate scale.

We anticipate that map-based and numeric indicators will eventually replace other indicators as better data become available.

Indicator Limitations and the Need for Professional Judgment

Good indicator sets should be comprehensive, accurately reflect watershed functionality, readily measurable, repeatable, provide data that can be unambiguously interpreted, convey an understanding of how the ecosystem functions, and provide insight into the cause-and-effect relationships between environmental stressors and the response of the ecosystem (Mulder and others 1999). However, indicator sets rarely exhibit all of these characteristics. Our application of indicators in this guide does not provide the level of detail expected from site specific watershed analysis or assessments (USDA/USDI 1998) nor is it intended to be a comprehensive evaluation of ecological conditions. Much like the Dow Jones Index gauges the strength of the stock market, watershed condition indicators rapidly assess the relative health of watersheds at a reconnaissance level. Additional detailed assessments will be needed to validate conclusions, identify specific watershed problems, and to arrive at treatment solutions.

As simple surrogates for complex ecological processes, indicators do not necessarily represent cause and effect relationships. Indicators are derived from studies that correlate the behavior of indicators with environmental response variables of interest. For example, increasing road density has been correlated with increasing sediment yield in many studies nationwide. However, the true set of environmental conditions that produce sedimentation are complex, unmeasured, or unknown. Numerous other factors including soils, geology, slope, and road condition also influence sediment yield. The result is that road density is not a perfect predictor of the impacts to sediment yield. The quality of an indicator ultimately depends on the quality of the research used to support it and its applicability to different environmental settings, but no one indicator is a perfect predictor of environmental response.

A second important consideration is that indicators work best when applied within the set of conditions under which they were developed, and the same indicator will have different interpretations in different ecological settings. For example, the naturally low volumes of large woody debris in many streams of the arid southwest would represent degraded conditions in the forests of western Oregon. Even the map-based indicators such as fire regime condition class, which have been developed for the entire United States, are subject to local professional validation and interpretation to assure that they are correctly applied. When used inappropriately, indicators and their attributes can provide misleading or incorrect conclusions. Numeric values should not be thought of as absolutes, but rather as diagnostic tools to promote discussion and understanding of relative watershed condition with respect to the rule set. ***As a result, this process necessarily relies on local professional expertise and judgment² to interpret the indicators and assess watershed condition.***

² Intuitive conclusions and predictions that are dependent upon an analyst's training, interpretation of facts, information, observations; and personal knowledge of the watershed being analyzed. Professional judgment in this context is exercised by a National Forest's interdisciplinary team.

Providing for National Consistency and Local Flexibility

Professional judgment is needed to properly interpret the indicators, but a certain level of consistency is needed to compare watersheds at the national level. Achieving consistent evaluation is a challenge when applying professional judgment across diverse ecosystems. To improve consistency, this classification system uses specific attributes along with quantitative and qualitative rule sets to assess watershed condition. The structured approach coupled with appropriate Regional oversight is designed to minimize bias among evaluators and promote consistent interpretation of indicators.

However, interpreting indicators also requires local flexibility because there are few simple indicators whose numeric range of values can be uniformly applied nationwide. For example, the natural range of water temperatures will have different values in warm water streams compared to high elevation trout stream but there is an interpreted threshold specific to each environment that indicates impairment. In addition, not all indicators apply in all environmental conditions and geophysical settings. For example, mass movement processes in the mountainous West are virtually non-existent in the Lake States of the Midwest.

To provide the needed flexibility, the classification process allows limited adjustment of core indicator attributes based on local data and conditions. To help maintain consistency, Regional or National oversight teams need to approve these changes. The goal of the process is to use the best available information and data to assess watershed condition and to interpret the range of watershed conditions in different physiographic setting in a correct and conceptually similar manner relative to the range of proper and impaired functionality.

Attributes can be adjusted in one of three ways:

- *Modify the default values of an attribute.* For example, the default ranges in the basic model for road density may be inappropriate for certain physiographic settings. The range and breaks between good, fair, and poor ratings can be adjusted if they are supported by Forest Plans or local analysis and data.
- *Substitute high-quality attribute data where appropriate.* For example, a Forest may have extensive Proper Functioning Condition survey data that could be used to rate attributes associated with the Riparian Vegetation Condition indicator. Alternatively, a Region, for example Alaska, may wish to substitute riparian forest age class structure as their indicator of riparian vegetation condition.
- *Rate an attribute as Not Applicable.* For example, a Forest lacking rangelands and grazing may exclude rangeland vegetation from their assessment of the terrestrial physical process category. A *Not Applicable* rating (N/A) can also be used for indicators or attributes not relevant within a particular geographical context. Only two indicators (forest cover and rangeland vegetation) and two attributes (large woody debris and mass wasting) may be rated N/A subject to Regional Oversight Team approval.

These types of adjustments provide the flexibility needed to account for local differences in individual watersheds while maintaining an acceptable level of regional and national consistency. Allowing Forests to adjust ratings of attributes based on local conditions and regional oversight achieves flexibility. National consistency in scoring is maintained by retaining a consistent set of indicators, averaging attribute scores within each indicator, and weight-averaging indicator scores by process category. National consistency is most important at the process category level because each Forest evaluates these fundamental ecosystem process categories in a manner appropriate to their geographic setting.

We anticipate that there will be instances, or locally unique circumstances, where the computed condition rating may not accurately reflect true on-the-ground conditions. In these cases, Forests will have the option of exercising an “override option” and replace the computed condition rating with the condition class judged to be correct. Typically, the override option would be used to designate severely impaired watersheds. Examples where the “override options” might be appropriate include situations such as (1) acid streams totally devoid of biological life, (2) water quality impairment due to chemical contamination, or (3) streams that are totally dewatered by diversions. In all of these examples, upland condition may be in excellent condition but the water body is clearly impaired.

Interdisciplinary teams should use the override option judiciously and rarely. Exercise of the override option will require written documentation and approval from the Regional Oversight Team. Use of the override option will be reviewed by the National Oversight Team annually to assure that it is being applied in an appropriate manner.

Classifying Individual Indicators

Each indicator attribute receives a rating. The ratings are expressions of the “best-fit” descriptor of the attribute for the entire 6th code watershed being classified. In the absence of established numeric criteria for most of the attributes, the boundaries between the attribute condition ratings were assigned by resource specialists working on the Watershed Condition Advisory Team using professional judgment guided by the conceptual condition descriptions below.

Condition Rating 1 is synonymous with “GOOD” condition. It is the expected indicator value in a watershed with high geomorphic, hydrologic, and biotic integrity relative to natural potential condition. The rating suggests that the watershed is “functioning properly” with respect to that attribute.

Condition Rating 2 is synonymous with “FAIR” condition. It is the expected indicator value in a watershed with moderate geomorphic, hydrologic, and biotic integrity relative to natural potential condition. The rating suggests that the watershed is “functioning at risk” with respect to that attribute.

Condition Rating 3 is synonymous with “POOR” condition. It is the expected indicator value in a watershed with low geomorphic, hydrologic, and biotic integrity relative to natural potential condition. The rating suggests that the watershed is “impaired or functioning at unacceptable risk” with respect to that attribute.

To conceptualize this, the suggested approach is to identify the upper and lower bounds for each indicator attribute to differentiate the desired conditions for that attribute (high integrity or high functionality relative to site potential) compared to the unacceptable or impaired functionality of the attribute in absolute terms. Conceptually, identifying the end points should be the easiest task to accomplish in any rating scheme. The remaining middle designation is then identified by default and may contain a wide range of conditions. Ratings are scaled and evaluated in an absolute sense from proper function to impaired function and not relative to a more limited range of attribute conditions that may occur on a particular National Forest.

The complete watershed condition rule set for indicators and attributes is contained in Appendix A. For each indicator, we provide a brief purpose statement, the rule set to use to determine the condition rating of each attribute, additional guidance pertaining to rating the indicator attributes, definitions, a brief rationale of how the indicator relates to watershed condition, and references. Careful reading of the “Additional Guidance” section for each indicator is essential for appropriate use of the rule set.

The example below illustrates the process of scoring an individual indicator on FS lands. The example indicator is Road and Trail Condition. The hypothetical watershed is in the upper Midwest where there are no unstable landforms susceptible to mass wasting. The watershed is heavily roaded having a road density of 2.5 mi/mi². Roads are well maintained but more than 25% are within 100 feet of water. The Forest ID Team decides that mass wasting is not an issue in this watershed and assigned the following ratings to road condition:

Road and Trail		
Attributes	Rating	Explanation
Open Road Density	3	Poor (Impaired Function)
Road Maintenance	2	Fair (Functioning at Risk)
Proximity to Water	3	Poor (Impaired Function)
Mass Wasting	N/A	N/A (the watershed is not susceptible to mass wasting)
INDICATOR RATING	2.7	Poor (Impaired Function)

The complete classification process for each watershed is described below:

- For each 6th level HUC watershed, all attributes for each of the 12 indicators is scored by the Forest interdisciplinary team as 1 (Good - Functioning Properly), 2 (Fair – Functioning at Risk), or 3 (Impaired Function) using written criteria and rule sets and the best available data and professional judgment.

- The attribute scores for each indicator are summed and averaged to produce an indicator score.
- The indicator scores within each ecosystem process category are then averaged to arrive at a process category score.
- The overall Watershed Condition Score is computed as a weighted³ averaged of the four process category scores.
- The Watershed Condition scores are tracked to one decimal point and reported as Watershed Condition Classes 1, 2, or 3. Class 1 = scores of 1.0 to 1.66; Class 2 = scores >1.66 and <2.33, and Class 3 = scores from 2.33 to 3.0.
- A separate scoring process is conducted for FS and non-FS lands within the watershed. Results will be reported for FS and non-FS lands and a watershed composite overall Watershed Condition Score (area weighted average of FS and non-FS lands).

Condition ratings will be assigned to FS ownerships, private lands, and the composite watershed. The composite score rates the whole watershed and includes Forest Service and all other ownerships, typically private land. The intent is to differentiate watershed conditions attributable to FS management and problems that the Forest Service can solve from those that are associated with others. We also wish to support the Secretary's call for an "all lands" approach to resource management.

Because we frequently lack data about the condition of non-FS lands, a simpler approach is applied to these ownerships. Non-FS lands will be assigned a subjective rating on a whole watershed basis (i.e., individual indicators and attributes will not be scored) and rated as either THE SAME AS, BETTER THAN, or POORER THAN FS lands in the watershed. If SAME AS is selected, the non-FS lands will be assigned the same numeric condition score as FS lands. If non-FS lands are not the same as FS lands, the non-FS lands will be designated simply as Class 1, Class 2, or Class 3 based on the best available knowledge. Forests are encouraged to rate non-FS lands equal to FS lands if there is doubt about the true condition. Forests may work with partner groups to classify non-FS lands, if they wish.

National Forests will complete the classification process using the Watershed Classification and Assessment Tracking Tool (WCATT), a Web-based application developed by the Natural Resource Information Systems (NRIS). The most current version of the WCATT User Guide can be downloaded from:

<http://sforge.fs.fed.us/sf/go/doc17445?nav=1>.

³ Process categories are weighted to reflect their relative contribution toward watershed condition from a national perspective. The aquatic physical and aquatic biological categories are weighted at 30% each because of their direct impact to aquatic systems (endpoint indicators). The terrestrial physical category is weighted at 30% because roads are typically one of the highest sources of impact to watershed condition. Terrestrial biological is weighted at 10% because these indicators have indirect impact to watershed condition.

Regional and National Oversight

This classification process relies on Washington Office and Regional Office oversight to provide for flexibility and consistency in application among National Forests. The Washington Office technical oversight role will be the primary responsibility of the Watershed, Fish, Wildlife, Air and Rare Plants staff assisted by members of the Watershed Condition Advisory Team due to the interdisciplinary nature of the classification process. Advisory team members provide technical input, expertise, and advice regarding the rule sets affecting their program areas.

The Washington Office will coordinate an annual meeting to discuss technical classification issues and resolve disputes. This will include as a minimum a review of the extent to which Regions permitted use of “Not Applicable” and the “Override” options.

National oversight roles and responsibilities include:

- Managing the national change process for the classification system,
- Assuring consistency of classification among the Regions,
- Providing and supporting development of national GIS data products for use in classification, and
- Providing direction and resolving disputes between Regions.

Regions will provide the first line of quality control and quality assurance in the classification process. Regions are encouraged to work collectively with their Forests to discuss interpretation of the rule set wording with the goal of achieving as much consistency as practicable among Forest units. Regions may wish to develop Regional additional guidance supplements to this guide that document local application, data sources, and interpretations. The composition of Regional Office Oversight Teams is left to the discretion of the Regions.

Regional oversight roles and responsibilities include:

- Assuring consistency of classification among the Forests in the Region,
- Assuring that Forests use interdisciplinary teams to perform classifications,
- Approving use or modification to attribute default value, substituting high-quality attribute data or alternative wording for attributes, and the use of the “Not Applicable” and “Override” options,
- Coordinating classification with adjoining Regions and National Forests, and
- Consulting with the Washington Office when significant modifications are approved.

Procedural Guidance

This watershed classification approach was specifically designed as a rapid, coarse filter, office assessment process to be completed by a Forest interdisciplinary (ID) team over a two week time period using professional judgment and relying on existing information, maps, and GIS layers.

Preparation Checklist

- Identify the composition and leadership of the Forest ID team that will classify watershed condition. Consider having someone from the Forest Land and Resource Planning staff as the team lead. The team should include technical specialists with expertise in the 12 technical condition indicators. Typically, a Forest ID Team will do the classification, but Forests may include District staffs. Specialists with long tenure and familiarity with the Forest can be especially valuable to the team because of the breadth of experience they provide.
- Designate a technical lead for each of the watershed condition indicators. For example, a hydrologist might lead water quality and water quantity assessments.
- Have each specialist review the rule set and additional guidance for their indicator to help them understand the types of data and information that are useful to rate the attributes for that indicator.
- Over a one week period, have each specialist assemble the available information in preparation for the ID Team classification process. The types of information will vary by discipline and may include Forest Inventory and Monitoring Reports, interpreted map products, or assessments done by others.
- Arrange for support from Forest GIS specialists to have them provide analysis support (e.g., road density and road proximity to water analysis) that summarizes data by 6th level HUCs. Obtain the most current national GIS data coverage relevant to the analysis such as 303d impaired streams, fire regime condition class, and insect and disease maps as well as local GIS data such as roads and trails, dams and diversions, active and abandoned mines, forest cover, recent large fires, etc.
- Have each technical specialist develop a preliminary rating for their indicator for each 6th level HUC that can be brought forward to the full ID Team process for discussion.

Classification Process Checklist

- Allow at least one week (5 days) for the ID Team classification process.
- Convene the team and discuss the rule set for classification with the intent of achieving a common understanding. At this time, the team should also discuss and reach agreement on any indicators and/or attributes (forest cover, rangelands, mass wasting, large woody debris) that they may wish to designate as “Not Applicable” to the Forest, any proposed changes to attribute thresholds (e.g. road density), or substitution of alternative attribute wording for some indicators. Prior to the actual meeting, discuss and obtain approval from your Regional Oversight Team.
- Ratings are to be determined using an interactive ID Team process. Individual specialists may offer their preliminary classification of an indicator rating score, but the team should pool their collective knowledge to arrive at the final rating. The process will go slowly for the first few watersheds as individuals begin to gain a common understanding of the rating approach and it may take several hours to classify the first watershed. Consider beginning with a watershed known to be in good condition and then rate one known to be in poor condition to help provide perspective on the range of existing conditions. The process will speed up noticeably after several iterations.
- Use the Interim National Watershed Condition Index as the Forest’s beginning point for classifying watershed condition. The national interim condition rating is intended to provide broad-scale national perspective regarding the spatial distribution of watershed condition and how the local Forest ratings fit within the context of national ratings. The index is based on 5th-level HUCs and uses nationally consistent GIS data layers provided by the Rocky Mountain Research Station (Brown and Froemke 2010). A simple 5-indicator, 3 class watershed integrity model is used to compute an index of watershed condition at a national scale. The indicators were evaluated using the FS Ecosystem Management Decision Support (EMDS) system decision support model and displayed as color-coded maps. The 5 indicators and the rationale for their inclusion are:
 - Roads where the density of roads in a watershed is a surrogate indicator of the amount of land disturbance within a watershed.
 - Water Quality where the presence of impaired water bodies not meeting State water quality standards is a measure of the degree to which watersheds are in an unacceptable condition.
 - Vegetation where fire regime condition class indicates departure from potential natural vegetation and is related to the risk of losing ecosystem components to catastrophic fires.
 - Aquatic Biota where the number of threatened and endangered aquatic species serves as a surrogate for the biological integrity of aquatic systems within a watershed.

- Insects and Disease where predicted forest tree mortality is an indicator of potential risk to watershed condition.

Each of the 5 indicators was categorized using FS Watershed Condition Classes (FSM 2521). Class 1 implies high integrity (functioning properly); Class 2 implies moderate integrity (functioning at risk); and Class 3 implies impaired function. The 5 indicators were overlaid in GIS and composite scores computed using the EMDS process to yield a Watershed Condition Class for each watershed (Class 1, 2, or 3). During FY 2011, index results will be replaced by National Forest classifications at the finer 6th-level HUC scale. Additional information and Interim Watershed Condition Index maps at national and regional scales can be downloaded from: <http://fsweb.wo.fs.fed.us/wfw/watershed/watershed-classification.html>

- Use the Watershed Condition Classification Tool (WCATT) to record ratings and capture notes. Display the WCATT form on a large screen. A second large screen display may be useful to display other relevant GIS data layers.

Annual and Periodic Reassessments

- The watershed condition classification will need updates on an annual basis for performance accountability. Concentrate on reassessing those watersheds that are known or suspected to have changed significantly from the previous year focusing on:
 1. Priority watersheds where improvement activities have been implemented,
 2. Watershed that have experienced large fires since the previous year, and
 3. Watersheds that have experienced extensive natural disturbance.
 Consistent with this approach the Watershed Condition Classification Tool has been designed so that the previous year's classification data can be rolled forward into the current year and only those watersheds that have changed will need to be modified.
- Conduct a more rigorous classification of all watersheds every five years; or sooner if conditions warrant. In all cases, use an ID Team to perform annual and periodic reassessments.

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Appendix A: Rule Set for Watershed Conditions Indicators and Attributes

1. Water Quality Condition

Purpose: This indicator addresses the expressed alteration of physical, biological, or chemical impacts to water quality.

CONDITION RATING RULE SET

1. Water Quality Condition Indicator	Minimal to no impairment of beneficial uses to the water bodies in the watershed.	Minor impairment of beneficial uses to the water bodies in the watershed.	Significant impairment of beneficial uses to the water bodies in the watershed.
Attributes	GOOD (1) Functioning Properly	FAIR (2) Functioning at Risk	POOR (3) Impaired
Impaired Waters (303d Listed)	No State listed impaired or threatened water bodies.	Less than 10% of the stream miles or lake area are listed on the 303d or 305b lists and not supporting beneficial uses.	10% or more of the stream miles or lake areas are water quality limited and not fully supporting beneficial uses as identified by a State Water Quality Agency integrated report (303d & 305b).
Water Quality (Not Listed)	The watershed has minor or no water quality problems. For example, no documented evidence of excessive sediment, nutrients, chemical pollution or other water quality issues above natural or background levels; no consumption advisories or contamination from abandoned or active mines; little or no evidence of acidification, toxicity, or eutrophication due to atmospheric deposition (see "Additional Guidance" related to mines and atmospheric deposition).	The watershed has moderate water quality problems. For example, consumption advisories in localized areas; minor contamination from active or abandoned mines; localized incidence of accelerated sediment, nutrients, chemicals, or infrequent, documented incidents of water contamination of public drinking water sources. Moderate evidence of acidification, eutrophication, or toxicity due to atmospheric deposition (see "Additional Guidance" related to mines and atmospheric deposition).	The watershed has extensive water quality problems. For example, consumption advisories over extended areas; excessive sediment, nutrients, chemicals, extensive contamination from active or abandoned mines; or frequent incidents of contamination in public drinking water sources. Strong evidence of acidification, eutrophication, or toxicity due to atmospheric deposition (see "Additional Guidance" related to mines and atmospheric deposition).

Additional Guidance:

1. Water quality should address both surface and ground water.
2. Consider the mainstream systems as being indicative of whole drainage system water quality, i.e. the composite representative of the condition of all the streams in the watershed.

3. Consider chronic water quality deterioration as well as short-term impacts in light of overall sustained impact to beneficial uses, i.e. both could be irreversible/irretrievable but are not always so.
4. Consider monitoring and/or inventory information available from internal and external sources.
5. Since State Water Quality Agency integrated reports (303d & 305b) are submitted only every two year, use the latest and best available information about the status of impaired waters.
6. Atmospheric deposition can affect watersheds by causing acidification (sulfur and nitrogen), eutrophication (nitrogen), or toxicity (mercury). Water chemistry and/or critical loads can be used to classify conditions. A number of sources of water chemistry data are available (EPA 2006, 2009) and have been compiled into a National database (USDA FS 2009). The most current guidance on using chemistry and critical loads for classification is available at www.fs.fed.us/air.
 - a. For areas where acidification is the major concern, use the following guidance for classification:
 - i. Condition Rating 1: All water sample sites from the most sensitive water body in the watershed (or a nearby watershed with similar lithology) show an acid neutralizing capacity (ANC) of 50 micro-equivalents per liter (ueq/L) or greater.
 - ii. Condition Rating 2: One or more water sample sites from the most sensitive water body in the watershed (or a nearby watershed with similar lithology) show an acid neutralizing capacity of greater than 20 ueq/L and less than 50 ueq/L.
 - iii. Condition Rating 3: One or more water sample sites from the most sensitive water body in the watershed (or a nearby watershed with similar lithology) show an acid neutralizing capacity of 20 ueq/L or less.
 - iv. Water bodies that are naturally acidic ($\text{DOC} \geq 5 \text{ mg/L}$ – EPA 2009) or low in buffering capacity due to the influence of wetlands or local geology should be assigned Condition Rating 1.
 - v. Where acid neutralizing capacity (ANC) data is lacking, consider rating the attribute using national deposition maps and lithology to find similar watersheds where ANC data is available.
 - b. In areas where eutrophication (nitrogen) is the primary issue, appropriate classification thresholds set by EPA (2009) for each Region can be found at www.fs.fed.us/air.
 - c. Where aquatic critical loads for sulfur or nitrogen are available (such as Sullivan et al. 2007), compare current deposition to the critical load and classify as follows:
 - i. Condition Rating 1: Sulfur and/or nitrogen deposition is more than 10% below the aquatic critical load.
 - ii. Condition Rating 2: Deposition is 0-10% below the aquatic critical load.

- iii. Condition Rating 3: Deposition is above the aquatic critical load.
- 7. Guidance for rating water quality effects from abandoned and active mines:
 - i. Condition Rating 1: Abandoned and active mines with no associated evidence of water quality contamination.
 - ii. Condition Rating 2: “Abandoned Mine with potential to adversely affect...” An abandoned mine where there is documented evidence of past mineral production which has resulted in facilities, equipment, materials or associated disturbance which have the potential to adversely affect surface or groundwater due to release or threat of hazardous substances, pollutants or contaminants. Abandoned Mines typically included in this category will have deposits of mine waste, tailings, ore or spent ore, open pits, shafts or adits which exhibit evidence of oxidation of sulfide minerals, lack or vegetation or other signs of toxicity. Use the same logic for active mines.
 - iii. Condition Rating 3: “Abandoned Mine known to be affecting...” An abandoned mine that has been determined to be adversely affecting surface or groundwater as a result of water quality sampling and testing. Use the same logic for active mines.

Definitions:

Impaired or threatened water body - Any water body that is listed according to section 303(d) of the Clean Water Act. The 303(d) list is a comprehensive public accounting of all impaired or threatened water bodies, regardless of the cause or source of the impairment or threat. A water body is considered impaired when it does not attain the water quality standards needed to support its designated uses. Standards may be violated due to an individual pollutant, multiple pollutants, thermal pollution, or an unknown cause of impairment. A water body is considered threatened if it currently attains water quality standards, but is predicted to violate standards by the time the next 303(d) list is submitted to EPA. The determination is made by individual State water quality management agencies

Designated beneficial uses - The desirable uses that water quality should support. Beneficial uses include drinking water supply, primary contact recreation (such as swimming), and aquatic life support. Each designated use has a unique set of water quality requirements or criteria that must be met for the use to be supported. A water body may have multiple beneficial uses. Designated beneficial uses are identified by each State water quality management agency.

Aquatic organism consumption advisories - Advisories issued by the Environmental Protection Agency or by State natural resource or other agencies that advise the public to limit or avoid consumption of certain fish, shellfish, mussels,

crayfish, or other aquatic organisms due to pollution. These advisories inform the public that high concentrations of chemical contaminants have been found in local fish and aquatic species and include recommendations to limit or avoid consumption of certain fish and wildlife species from specific water bodies.

Abandoned Mines - Facilities, equipment, material and associated surface disturbance resulting from past mineral exploration or development, for which there is no current authorization and no evidence of current owner/operator.

Hazardous substances, pollutants or contaminants - Hazardous substances, pollutants and contaminants defined by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and its implementing regulations.

Acid neutralizing capacity - A measure of a water body's ability to buffer acid compounds, defined as the difference between cations of strong bases and anions of strong acids.

Critical Load - The amount of deposition of an atmospheric pollutant below which no harmful ecological effects occur. Critical loads can be calculated for both acidity and nutrient nitrogen in terrestrial and aquatic systems.

Lithology - The gross physical character of a rock or rock formation described in terms of its structure, color, mineral composition, grain size, and arrangement of its component parts; all those visible features that in the aggregate impart individuality to a rock formation.

Eutrophication - Increased growth of biota and an increasing rate of productivity that is accelerated over the rate that would have occurred naturally.

Rationale for Indicator:

Nonpoint source pollution, defined as water pollution that comes from many different sources in a watershed, is the leading remaining cause of water quality problems in the United States with polluted runoff from agriculture, silvicultural activities, and atmospheric deposition being among the leading causes (EPA 2007). Because nonpoint source pollutants are primarily derived from runoff generated from watershed surfaces, watershed condition and water quality are closely linked. The effects of nonpoint source pollutants on specific waters vary and may not always be fully assessed. However, we know that these pollutants have harmful effects on drinking water supplies, recreation, fisheries, and wildlife. In a recent report by EPA (2005), 45% of the water bodies assessed by State water quality agencies were reported as impaired or not clean enough to support their designated uses, such as fishing and swimming.

Indicator References:

- Sullivan, T.J., B.J. Cosby, K.U. Snyder, A.T. Herlihy and B. Jackson. 2007. Model-Based Assessment of the Effects of Acidic Deposition on Sensitive Watershed Resources in the National Forests of North Carolina, Tennessee, and South Carolina. see: http://199.128.173.141/acid_dep/
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2. Water Quantity Condition

Purpose: This indicator addresses changes to the natural flow regime with respect to the magnitude, duration, or timing of natural streamflow hydrographs.

CONDITION RATING RULE SET

2. Water Quantity Condition Indicator	Stream hydrographs have no or minor departure from natural conditions.	Stream hydrographs have moderate recognized departures from natural conditions part of the year.	The magnitude, duration, and/or timing of annual extreme flows (low and/or high) significantly depart from the natural hydrograph.
Attributes	GOOD (1) Functioning Properly	FAIR (2) Functioning at Risk	POOR (3) Impaired
Flow Characteristics	The watershed lacks significant man-made reservoirs, dams, and diversion facilities. The watershed has primarily free flowing rivers, streams, unmodified lakes, and no or limited ground water withdrawals. Stream hydrographs have no or minor alteration from natural (unaltered by anthropogenic actions) conditions.	The watershed contains dams and diversion facilities which are operated to partially mimic natural hydrographs. A departure from a natural hydrograph occurs during periods other than extreme flows (lows and/or highs). Peaks and base flows are maintained but changes to the timing, rate of change and/or duration of mid-range discharges occurs.	Dams and diversion facilities are operated so that they fail to mimic natural hydrographs. The magnitude, duration, and/or timing of annual extreme flows (low and/or high) significantly depart from the natural hydrograph. Commonly, the timing and the rate of change in flows do not correlate with expected seasonal changes.

Additional Guidance:

1. Relate existing conditions to historic conditions and reference conditions. The natural hydrograph baseline is streamflows unaltered by anthropogenic actions. Emphasis is on the permanent, long-term effects of water diversions and water control features rather than flow changes due to vegetation management.
2. Consider both the mainstream and tributaries when evaluating changes to flow hydrology. In most cases, depending on their extent and magnitude, flow changes to tributaries will be reflected in cumulative changes observable in the mainstream stream.
3. Concentrate evaluation on effects to perennial, main stem streams rather than headwater tributaries or intermittent flows, except in arid or semi-arid regions where intermittent or interrupted flows are important components of the hydrograph.
4. The scale of the impact should be such that it results in measurable changes to the hydrograph. For example, water yield changes resulting from vegetation management would generally not be included unless it was extensive and persistent (e.g., extensive deforestation, urbanization, wildfire, dams, diversions, disease and insects or other disturbances that significantly and persistently alter runoff).

5. Groundwater pumping would generally need to be for large-scale industrial or large municipality use to measurably influence streamflow. Household groundwater use for domestic purposes would generally not qualify unless a watershed was developed to such an extent that it was closed to additional well developments by State water resource authorities.
6. Consider the effects of transbasin diversions with respect to both the gaining and receiving streams.

Definitions:

Natural Hydrograph - A hydrograph representing the natural seasonal flows of a river without the moderating influence of human-created features (dams, canals, etc.) or management actions.

Rationale for Indicator:

Watershed condition has large role to play in the magnitude, frequency, and timing of runoff from a watershed. The quantity and timing of streamflow are critical components of water supply, water quality, and the ecological integrity of river systems. The effects of human alteration on the natural flow regimes of rivers and ecological processes are now reasonably well understood (Poff et al. 1997). Modification of natural hydrologic processes disrupts the dynamic equilibrium between the movement of water and the movement of sediment that exists in free-flowing rivers (Dunne and Leopold 1978). This disruption alters physical habitat characteristics, including water temperature, oxygen content, water chemistry, and substrate composition, and adversely changes the composition, structure, or function of aquatic, riparian, and wetland ecosystems (Bain et al. 1988). The result is that many rivers no longer support socially valued native species or sustain healthy ecosystems (NRC 1992).

Indicator References:

- Bain, M.B., J.T. Finn, and H.E. Booke. 1988. Stream flow regulation and fish community structure. *Ecology* 69:382-392.
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Poff, N.L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegard, B.D. Richter, R.E. E. Sparks and J.C. Stromberg. 1997. The Natural Flow Regime, A paradigm for river conservation and restoration. *BioScience* 47 (11):769-784.

3. Aquatic Habitat Condition

Purpose: This indicator addresses aquatic habitat condition with respect to habitat fragmentation, large woody debris, and channel shape and function.

CONDITION RATING RULE SET

3. Aquatic Habitat Condition Indicator	The watershed supports large continuous blocks of high quality aquatic habitat and high quality stream channel conditions.	The watershed supports medium to small blocks of contiguous habitat. Some high quality aquatic habitat is available, but stream channel conditions show signs of being degraded.	The watershed supports small amounts of continuous high quality aquatic habitat. Most stream channel conditions show evidence of being degraded by disturbance.
Attributes	GOOD (1) Functioning Properly	FAIR (2) Functioning at Risk	POOR (3) Impaired
Habitat Fragmentation (including Aquatic Organism Passage)	Fragmentation of habitat is not a serious concern (>95% of historic aquatic habitats are still connected).	Aquatic habitat fragmentation is increasing due to temperature, aquatic organism passage blockages, or dewatering (only 25% - 95% of the historic aquatic habitats are still connected).	Aquatic habitat fragmentation due to temperature, blockages, or dewatering is a serious concern (>25% of the historic aquatic habitats are no longer connected).
Large Woody Debris	In aquatic and riparian systems that evolved with wood, large woody debris is present and continues to be recruited into the system at near natural rates.	In aquatic and riparian systems that evolved with wood, large woody debris is present but is recruited into the system at less than natural rates due to riparian management activities.	In systems that should contain large wood as an ecosystem component, it is lacking resulting in poor riparian or aquatic habitat conditions including bank destabilization, little pool formation, and little microclimate maintenance.
Channel Shape and Function	Channel width-to-depth ratios exhibit the range of conditions expected in the absence of human influence. Less than 5% of the stream channels show signs of widening. Channels are vertically stable, with isolated locations of aggradation or degradation as would be expected in near natural conditions. The distribution of channels with floodplain connectivity is close to that found in reference watersheds of similar size and geology.	Channel width-to-depth and vertical stability are maintained except where riparian vegetation has been disturbed. From 5 to 25% of the stream channel have seen an increase in width-to-depth ratios. Channel degradation and/or aggradation are evident but limited to relatively small sections of the channel network. Evidence of downcutting so that some stream channels are no longer connected to their floodplain.	More than 75% of channels have width-to-depth ratios greater than expected under near-natural conditions. The size and extent of gullied sections of channels are extensive, currently increasing, or have increased recently. Many streambanks show signs of active erosion above that expected naturally. Channel degradation and/or aggradation are evident and widespread due to unstable streambeds and banks. Many (>50%) of the stream channels are disconnected from their floodplain or are braided channels due to increased sediment loads.

Additional Guidance:

1. If Forest Plan aquatic habitat direction exists for habitat fragmentation, large wood, or channel shape and function, use the local thresholds derived from Forest Plan standards and guidelines to determine the appropriate rating for the attributes.
2. Channels lower in the watershed (fish bearing) and response reaches (<3% gradient), should be the focus of this evaluation. Consider the length of response reaches in the watershed, and estimate the amount of channel that meets the criteria for the class.
3. Large Woody Debris: Rate this attribute “not applicable” if the aquatic and riparian systems in the watershed evolved without wood and the presence of wood is not an important process. Not applicable will likely have limited application to some western rangeland watersheds.
4. In aquatic habitats lacking aquatic biota and/or perennial habitat (e.g., some Southwest desert streams), evaluate conditions with respect to what would be expected to be there under natural conditions, absent human-induced impacts.

Definitions:

Floodplain Connectivity - In channels with existing or historic floodplains, floodplain connectivity refers to the ability of flows greater than bankfull to overflow on to the vegetated floodplain without accelerated impact to streambanks. Floodplain connectivity may be lost through the construction of levees, or through downcutting of channels because of improper road location and construction, overgrazing, storage dams, or increased flow or sediment. Incised channels lack floodplain connectivity.

Aquatic Habitat Fragmentation - Habitat fragmentation occurs when a large region of habitat have been degraded or fragmented into a collection of smaller patches of non-connected habitat. Major causes of aquatic habitat fragmentation are dams, diversions, mines, roads, inadequate culverts, and increased stream temperatures that prevent fish from moving freely throughout an aquatic system.

Response Channel Reaches - Low gradient (generally <3%) transport limited channels in which significant morphologic adjustment occurs in response to increased sediment supply as defined by Montgomery and Buffington (1993). Response channels generally correspond to Rosgen C, D, E, and F channel types (Rosgen 1996). These areas are evaluated because they are the most susceptible to change from disturbance.

Rationale for Indicator:

Watersheds in good condition tend to retain most of their natural heterogeneity and complexity. This means preserving the lateral, longitudinal, and vertical connections between system components in addition to the natural spatial and temporal variability

of these components (Naiman et al. 1992). Floodplain connectivity speaks to maintenance of the vertical component of stream channels and provides for off-channel habitat among other features. Habitat fragmentation speaks to longitudinal component of healthy systems. Aquatic habitat fragmentation by fish passage blockages, dewatering, or temperature increases, along with simplification from activities including channelization, channel bed sedimentation, woody debris removal, and flow regulation, results in loss of diversity within and among native fish species (Lee et al. 1997). Maintaining heterogeneity and complexity of aquatic organism habitat at scales from microhabitats to entire basins has been recognized as an important influence on species diversity and ecosystem stability (Sedell et al. 1990).

Indicator References:

- Lee, D.C. and 21 other authors. 1997. An assessment of ecosystem components in the Interior Columbia Basin and Portions of the Klamath and Great Basin. Volume 3. Broad-scale Assessment of Aquatic Species and Habitats. USDA Forest Service General Technical Report PNW-GTR-405. Portland, Oregon.
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4. Aquatic Biota Condition

Purpose: This indicator addresses the distribution, structure, and density of native and introduced aquatic fauna.

CONDITION RATING RULE SET

4. Aquatic Biota Condition Indicator	All native aquatic communities and life histories appropriate to the site and watershed are present and self maintaining.	The watershed is a stronghold for one or more native aquatic communities when compared to other sub-basins within the native range. Some life histories may have been lost or range has been reduced within the watershed.	The watershed may support small widely scattered populations of native aquatic species. Exotic and/or aquatic invasive species are pervasive.
Attributes	GOOD (1) Functioning Properly	FAIR (2) Functioning at Risk	POOR (3) Impaired
Life Form Presence	Greater than 90% of expected aquatic life forms and communities are present based on the potential natural communities present.	From 70 to 90% of expected aquatic life forms and communities are present based on the potential natural communities present.	Less than 70% of expected aquatic life forms and communities are present based on the potential natural communities present.
Native Species	Most native aquatic species and life histories that would be expected based on potential natural communities are present and self maintaining. There has been limited intermixing of native species genetics with outside sources, such as can occur when moving aquatic species from one aquatic habitat to another.	Residual and at times isolated native endemic species that would be expected based on potential natural communities may be located in specific aquatic habitats. Some non-native species may be present but native species are self sustaining where found.	Exotic and/or aquatic invasive species are present and have mostly replaced native aquatic species. Legacy management effects to habitat from chemicals, sediment or other pollution may limit the knowledge available on endemic native species. Aquatic habitat is disconnected by passage or flow barriers.
Exotic and/or Aquatic Invasive Species	Exotic and/or aquatic invasive species may be present but they have not greatly altered condition of native species (<25% of the historic aquatic life bearing habitats have exotic and/or aquatic invasive species present, spread of exotics and/or aquatic invasives have been minimal over the last decade).	Exotic and/or aquatic invasive species are generally present and have lowered the health and sustainability of native species (between 25 and 50 percent of the historic native aquatic life bearing habitats have exotic and/or aquatic invasive species present and/or there has been an expansion of exotic and/or aquatic invasive species over the last decade).	Exotic and/or aquatic invasive species are present and have greatly lowered the condition of native aquatic species (>50 percent of the historic native fish bearing stream have exotic and/or aquatic invasive species present and/or there has been an expansion of non native exotic and/or aquatic invasive species over the last decade.

Additional Guidance:

1. Life Form Presence: Avoid focus on single species; focus on communities.
2. Exotic and/or aquatic invasive species: The presence of exotic and/or aquatic invasive species or communities is used as an indicator of altered or impaired conditions. Although exotic and/or aquatic invasive species can significantly affect native aquatic faunal integrity, intra-species interactions are not considered for this assessment. For this assessment, the widespread presence of exotic and/or aquatic invasive species indicates poor conditions. For example, if you note the presence of bluegill in an area that historically supported native rainbow trout, and you find in your records that water temperatures and flow conditions are now favoring bluegill and are not providing suitable habitat conditions for trout, your conclusion is that the habitat is in poor condition and the presence of bluegill is an indicator of this condition.

Definitions:

Native fauna - Any faunal species native to a watershed.

Exotic species - Non-native species that are not considered invasive.

Aquatic invasive - Non-native species that are also considered invasive.

Rationale for Indicator:

Native fish and other native aquatic biota have been adversely impacted by land and watershed development, habitat loss, direct human harvest, and increased competition from introduced exotic and/or aquatic invasive species. Introduced species and stocks are major threats to native fishes and native aquatic biota by way of predation, competition, introduction of diseases and parasites for which native species lack resistance, environmental modification, inhibition of reproduction, and hybridization (Moyle et al. 1986, Nehlsen et al. 1991). Non-native introductions frequently have effects that cascade through entire ecosystems and compromise ecological structure and function in unforeseen ways (Winter and Hughes 1995). Although introductions have increased fishing opportunities, the ecological consequences have been high and the dramatic expansion of non-native species has left many systems compromised (Angermeier and Karr 1994).

Indicator References:

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5. Riparian/Wetland Vegetation Condition

Purpose: This indicator addresses the function and condition of native riparian vegetation along streams, water bodies and wetlands.

CONDITION RATING RULE SET

5. Riparian Vegetation Condition Indicator	Native vegetation is in proper functioning condition throughout the stream corridor or along wetlands and water bodies.	Disturbance partially compromises proper functioning condition of native vegetation attributes in stream corridor areas or along wetlands and water bodies.	A large percent of native vegetation attributes along stream corridors, wetlands and water bodies are not in proper functioning condition.
Attributes	GOOD (1) Functioning Properly	FAIR (2) Functioning at Risk	POOR (3) Impaired
Vegetation Condition	Native mid to late seral vegetation appropriate to the sites potential dominates the plant communities and is vigorous, healthy and diverse in age, structure, cover and composition on >80% of the riparian/wetland areas in the watershed. Sufficient reproduction of native species appropriate to the site is occurring to ensure sustainability. Mesic herbaceous plant communities occupy most of their site potential. Vegetation is in a dynamic equilibrium appropriate to the stream or wetland system.	Native vegetation demonstrates a moderate loss of vigor, reproduction and growth, or changes in composition, especially in areas most susceptible to human impact. Areas displaying light to moderate impact to structure, reproduction, composition and cover may occupy 25 to 80% of the overall riparian area with only a few areas displaying significant impacts. Up to 25% of the species cover or composition occurs from early seral species and/or there are some localized but relatively small areas where early seral vegetation dominates, but the communities across the watershed are still dominated by mid to late seral. Xeric herbaceous communities exist where water relationships have been altered but are relatively small, localized, generally are not continuous across large areas, and do not dominate across the watershed.	Native vegetation is vigorous, healthy and diverse in age, structure, cover and composition on <75% of the riparian/wetland areas in the watershed. Native vegetation demonstrates a noticeable loss of vigor, reproduction and growth, and changes in composition as compared with the site potential communities throughout areas most susceptible to human impact. In these areas, cover and composition are strongly reflective of early seral species dominance although there will be late seral and mid seral species present, especially in pockets. Mesic dependent herbaceous vegetation is limited in extent with many lower terraces dominated by Xeric species most commonly associated with uplands. Reproduction of mid and late seral species is very limited. For much of the area, the water table is disconnected from the riparian area and the vegetation reflects this loss of available soil water

Additional Guidance:

1. Use the following riparian/wetland vegetation attribute questions to guide your evaluation of the existing condition of riparian vegetation in the watershed (Prichard et al. 1988). In all cases, evaluate the site relative to the appropriate site potential (PNC) vegetation:
 - Is there a diverse age-class distribution of native riparian-wetland vegetation (recruitment for maintenance/recovery)?
 - Is there a diverse composition of native riparian-wetland vegetation (for maintenance/recovery)?
 - Are native species present that indicate maintenance of riparian-wetland soil moisture characteristics and connectivity between the riparian/wetland vegetation and the water table typical of riparian/wetland systems in the area?
 - Is streambank native vegetation comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events?
 - Is adequate native riparian-wetland vegetative cover present to protect banks and dissipate energy during high flows?
 - Do native riparian-wetland plants exhibit high vigor?
 - Are native plant communities an adequate source of coarse and/or large woody material (for maintenance/recovery)?
2. If Forest Plan riparian management direction exists for riparian/wetland vegetation, use the local thresholds derived from Forest Plan standards and guidelines to determine the appropriate rating for this attribute. For example, riparian timber stand conditions may be appropriate in some ecosystems as a measure of riparian vegetation condition while riparian/wetland herbaceous vegetation conditions are appropriate for other systems.
3. Where PFC field surveys are available (Prichard et al. 1994), rate the Proper Functioning Condition category as Condition Class 1, the Functional - At Risk category as Condition Class 2, and the Nonfunctional category as Condition Class 3 based on the percent of riparian areas in each category.

Definitions:

Riparian zone, riparian area, stream corridor - The interface between land and the banks of a stream, river, or other body of water. We use the term riparian in its broadest sense to include areas adjacent to a stream, river, or lake recognizing that a diverse mixture of different definitions exists across the United States. Plant communities along these water margins are called riparian vegetation and are characterized by hydrophytic plants.

Wetlands - Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas.

Proper Functioning Condition (Functioning Properly) - Riparian-wetland health (functioning condition), an important component of watershed condition, refers to the ecological status of vegetation, geomorphic, and hydrologic development, along with the degree of structural integrity exhibited by the riparian-wetland area. Riparian-wetland areas in Proper Functioning Condition exist when adequate vegetation, landform, or large woody debris is present to dissipate stream energy associated with high waterflow, thereby reducing erosion and improving water quality; filter sediment, capture bedload, and aid floodplain development; improve flood-water retention and ground-water recharge; develop root masses that stabilize streambanks against cutting action; develop diverse ponding and channel characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, waterfowl breeding, and other uses; support greater biodiversity.

Functional- at Risk (Functioning at Risk) - Riparian-wetland areas that are in functional condition, but one or more existing soil, water, or vegetation attributes makes them susceptible to degradation.

Nonfunctional (Impaired) - Riparian-wetland areas that clearly are not providing adequate vegetation, landform, or large woody debris to dissipate stream energy associated with high flows, and thus are not reducing erosion, improving water quality, etc.

Rationale for Indicator:

Riparian and wetland areas are the interface between terrestrial and aquatic ecosystems and are an integral part of the watersheds in which they occur. Consequently, the health of these areas is closely interrelated to the condition of the surrounding watershed (DeBano and Schmidt 1989, Hornbeck and Kochenderfer 2000). The health of riparian corridors is dependent on the storage and movement of sediment through the channel system but also on the movement of sediment and water from surrounding hillslopes into the channel system. These processes can be altered by human induced and natural disturbances either indirectly to the watershed or directly to riparian areas themselves by livestock grazing, road construction, mining, irrigation diversion, channel modification, flooding, wildfire and similar disturbances (Baker et al. 2004, NRC 2002). One good measure of riparian/wetland health is the ecological condition of its vegetation relative to reference conditions.

Indicator References:

Baker M.B., P.F. Ffolliott, L.F. DeBano, D.G. Neary (editors), 2004. Riparian areas of the Southwestern United States: Hydrology, ecology and management. CRC Press. Boca Raton, FL.

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6. Road and Trail Condition

Purpose: This indicator addresses changes to the hydrologic and sediment regimes due to the density, location, distribution, and maintenance of the road and trail network.

CONDITION RATING RULE SET

6. Road and Trail Condition Indicator	The density and distribution of roads and linear features within the watershed indicates the hydrologic regime is substantially intact and unaltered.	The density and distribution of roads and linear features within the watershed indicate there is a moderate probability that the hydrologic regime is substantially altered.	The density and distribution of roads and linear features within the watershed indicate there is a higher probability that the hydrologic regime (timing, magnitude, duration, and spatial distribution of runoff flows) is substantially altered.
Attributes	GOOD (1) Functioning Properly	FAIR (2) Functioning at Risk	POOR (3) Impaired
Open Road Density	Default road/trail density: < 1 mi/mi ² , <u>OR</u> a locally determined threshold for good conditions supported by Forest Plans or analysis and data.	Default road/trail density: 1 - 2.4 mi/mi ² , <u>OR</u> a locally determined threshold for fair conditions supported by Forest Plans or analysis and data.	Default road/trail density: >2.4 mi/mi ² , <u>OR</u> a locally determined threshold for poor conditions supported by Forest Plans or analysis and data.
Road and Trail Maintenance	BMPs for the maintenance of designed drainage features are applied to >75% of the roads, trails, and water crossings in the watershed.	BMPs for the maintenance of designed drainage features are applied to 50 to 75% of the roads, trails, and water crossings in the watershed.	BMPs for the maintenance of designed drainage features are applied to <50% of the roads, trails, and water crossings in the watershed.
Proximity to Water	No more than 10% of road/trail length is located within 300 feet of streams and water bodies or hydrologically connected to them.	10 - 25% of road/trail length is located within 300 feet of streams and water bodies or hydrologically connected to them. .	More than 25% of road/trail length is located within 300 feet of streams and water bodies or hydrologically connected to them. .
Mass Wasting	Very few roads are on unstable landforms or rock types subject to mass wasting with little evidence of active movement or evidence of road damage. There is no danger of large quantities of debris being delivered to the stream channel due to mass wasting.	Few roads are on unstable landforms or rock types subject to mass wasting with moderate evidence of active movement or road damage. There is some danger of large quantities of debris being delivered to the stream channel. It is not a primary concern in this watershed.	Most roads are on unstable landforms or rock types subject to mass wasting with extensive evidence of active movement or road damage. Mass wasting that could deliver large quantities of debris to the stream channel is a primary concern in this watershed.

Additional Guidance:

1. For the purposes of this reconnaissance-level assessment, the term “road” is broadly defined to include roads and all lineal features on the landscape that typically influences watershed processes and conditions in a manner similar to roads. Roads therefore include FS system roads (paved or non-paved) and any temporary roads (skid trails, legacy roads) not closed or decommissioned

- including private roads in these categories. Other linear features that might be included based on their prevalence or impact in a local area are motorized (ORV, ATV) and non-motorized (recreational) trails and linear features such as railroads. Properly closed roads should be hydrologically disconnected from the stream network. If roads have a closure order but are still contributing to hydrological damage they should be considered open for the purposes of road density calculations.
2. **Open Road Density:** Although default road density guidelines (USFWS 1998, 2000) for good, fair, and poor conditions are provided, Forests may deviate from the default values based on local analysis and/or Forest Plan standards and guideline. For example, existing local or regional planning processes, publications, or other analyses may have established thresholds that are more pertinent to local conditions. The selected default road density guidelines were derived from U.S. Fish and Wildlife Service guidance that covered a large geographical area, i.e., most of the western United States.
 3. **Mass Wasting:** Mass movement is rated only with respect to the extent and effect it is associated with roads and effects to aquatic resources. Areas that are inherently unstable or at risk from mass movement are not rated.
 4. **Mass Wasting:** Geographical areas where mass wasting is not a significant process, may be rated as “not applicable.” Typically this designation would be applied over a broad geographic area such as an entire National Forest. Coordination with the Regional Oversight Team is suggested to assure consistency among adjacent units.

Definitions:

Hydrologically connected - Any road segment that, during high runoff event has a continuous surface flow path between the road prism and a natural stream channel is a hydrologically connected road segment. The proximity of roads to streams is a surrogate for identifying hydrologically connected roads to streams.

Mass wasting - The geomorphic process by which soil, regolith, and rock move downslope under the force of gravity. Mass wasting may also be known as slope movement or mass movement. It encompasses a broad range of gravity-driven rock, soil, or sediment movements, including weathering processes. Types of mass wasting include creep, slides, flows, topples, and falls and they are differentiated by how the soil, regolith, or rock moves downslope as a whole.

Unstable landforms, geologic types, and landslide prone areas - Areas determined to be unstable by individual National Forests using exiting soil resource inventories (SRI), terrestrial ecological unit inventories (TEUI), or geologic inventories or maps.

Rationale for Indicator:

Roads affect watershed condition because more sediment is contributed to streams from roads and road construction than any other land management activity. Roads

directly alter natural sediment and hydrologic regimes by changing streamflow patterns and amounts, sediment loading, transport, and deposition, channel morphology and stability, water quality and riparian conditions within a watershed (Gibbons and Salo 1973, Dunne and Leopold 1978, Copstead et al. 1997). Road maintenance can also increase sediment routing to streams by creating areas prone to surface runoff, altering slope stability in cut and fill areas, removal of vegetation, and altering drainage patterns (Reid and Dunne 1984, Megahan 1978, Burroughs and King, 1989, Luce and Black 2001). Road density is known to play a dominant role in human-induced augmentation of sediment supply by erosion and mass wasting in upland forested landscapes in the Pacific Northwest (Cederholm et al. 1981, Furniss et al. 1991) and it is reasonable to assume that similar relationships exist elsewhere. Road-related mass soil movements can continue for decades after roads have been constructed and long-term slope failures frequently occur following road construction and timber harvest (Megahan and Bohn 1989).

Indicator References:

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- U.S. Fish and Wildlife Service (USFWS). 2000. USFWS Matrix: A framework to assist in making Endangered Species Act determinations of effect for individual or grouped actions at the bull trout subpopulation watershed scale. Appendix 9 of the Interior Columbia Basin Ecosystem Management Project, Supplemental Environmental Impact Statement, U.S. Forest Service and Bureau of Land Management, Boise, Idaho. March, 2000.

7. Soil Condition

Purpose: This indicator addresses alteration to natural soil condition, including productivity, erosion and chemical contamination.

CONDITION RATING RULE SET

7. Soil Condition Indicator	Minor or no alteration to reference soil condition, including erosion, productivity, and chemical characteristics is evident.	Moderate amount of alteration to reference soil condition is evident. Overall soil disturbance is characterized as moderate.	Significant alteration to reference soil condition is evident. Overall soil disturbance is characterized as extensive.
Attributes	GOOD (1) Functioning Properly	FAIR (2) Functioning at Risk	POOR (3) Impaired
Soil Productivity	Soil nutrient and hydrologic cycling processes are functioning at near site potential levels, and the ability of the soil to maintain resource values and sustain outputs is high in the majority of the watershed.	Soil nutrient and hydrologic cycling processes are impaired and the ability of the soil to maintain resource values and sustain outputs is compromised in 5-25 % of the watershed.	Soil nutrient and hydrologic cycling processes are impaired and the ability of the soil to maintain resource values and sustain outputs is compromised in >25 % of the watershed.
Soil Erosion	Evidence of accelerated surface erosion is generally absent over the majority of the watershed.	Evidence of accelerated surface erosion occurs over < 10% of the watershed OR rills and gullies are present but are generally small, disconnected, poorly defined, and not connected into any pattern.	Evidence of accelerated surface erosion occurs over > 10% of the watershed OR rills and gullies are actively expanding, well-defined, continuous, and connected into a definite pattern.
Soil Contamination	There are no substantial areas of soil contamination in the watershed. When atmospheric deposition is a source of contamination, sulfur and/or nitrogen deposition is more than 10% below the terrestrial critical load.	Limited areas of soil contamination may be present, but they do not have a substantial effect on overall soil quality. When atmospheric deposition is a source of contamination, sulfur and/or nitrogen deposition is 0-10% below the terrestrial critical load.	Extensive areas of soil contamination may be present. When atmospheric deposition is a source of contamination, sulfur and/or nitrogen deposition is above the terrestrial critical load.

Additional Guidance:

1. If Forest or Regional direction exists for soil quality or soil management, these local thresholds may be used to determine the appropriate rating for soil attributes.
2. Soil nutrient and hydrologic cycling processes are evaluated using available relevant soil properties such as compaction, porosity, infiltration, bulk density, organic matter, soil cover, microbial activity, or other appropriate indicators.
3. Soil erosion should not double count road-related erosion effects that are considered in the road and trail condition indicator.

4. **Atmospheric Deposition:** Compare current deposition to site-specific terrestrial critical loads for acidity and/or nutrient nitrogen (Geiser et al. 2010, Pardo et al. in review), or the best available critical loads calculated for similar sites in the region. Where acidification is the primary concern and site-specific critical loads are absent, use the risk assessment map of exceedence of critical loads (based on McNulty et al. 2007) to classify the watershed. Current information (including directions to GIS coverages) for site-specific, regional and national scale critical loads is available at www.fs.fed.us/air.

Definitions:

Critical Load - The amount of deposition of an atmospheric pollutant below which no harmful ecological effects occur. Critical loads can be calculated for both acidity and nutrient nitrogen in terrestrial and aquatic systems.

Soil Condition/Soil Quality - The capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation and ecosystem health. (USDA Forest Service, 2010)

Reference Soil Condition - The condition of the soil to which functional capacity is compared. Using indicators, soil quality is usually assessed by comparing a management system to a reference condition. The reference condition may be represented with 1) baseline measurements taken previously at the same location; 2) established and achievable indicator values such as salinity levels related to salt tolerance of crops; and 3) measurements from the same or similar soil under the reference state or inherent or attainable conditions (Tugel et al. 2008).

Rationale for Indicator:

Natural soil condition includes evaluation of erosion, nutrients, productivity, and the physical, chemical, and biological characteristics of the soil (USDA FS 2009). Soil condition is related to watershed condition due to significant water supply benefits associated with development of forest soils that promote infiltration and high-quality water. Forest soils, with a litter layer, high organic content and large macropore fraction promote rapid infiltration and minimize erosive overland flow (Ice 2009). In other ecosystems, soil supplies air, water, nutrients, and mechanical support for the sustenance of plants. It also receives and processes rainfall and controls how much becomes surface runoff, how much is stored for slow, sustained delivery to stream channels, and how much is stored and used for soil processes (Neary et al. 2005). Management activities, such as intensive grazing, logging, recreational activity, and other disturbances, can lead to reduced soil structure, soil compaction, and damage to or loss of vegetative cover. These activities contribute to increased surface runoff resulting in soil erosion, loss of nutrients, and result in a decrease in soil productivity (Meehan and Platts 1978). The soil contamination attribute addresses various sources of contaminants including abandoned mines, illegal dumping, drug labs, spills,

atmospheric deposition and others. For atmospheric sources, the critical load standard addresses the impact of air pollution (sulfur and nitrogen) deposition on forest soils. Sulfur and/or nitrogen deposition estimates above the critical load for soil indicates the potential for significant harmful effects to the forest ecosystem through the accelerated loss of base cations, a decrease in soil pH, an increased risk of biologically toxic levels of aluminum released from the soils, or nitrogen in excess of and detrimental to biological demand.

Indicator References:

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8. Fire Effects and Regime Condition

Purpose: This indicator addresses the potential for altered hydrologic and sediment regimes due to departures from historical ranges of variability in vegetation, fuel composition, fire frequency, fire severity, and fire pattern.

CONDITION RATING RULE SET

8. Fire Effects & Regime Condition Indicator	Low likelihood of losing defining ecosystem components due to the presence or absence of fire	Moderate likelihood of losing defining ecosystem components due to the presence or absence of fire.	High likelihood of losing defining ecosystem components due to the presence or absence of fire.
Attributes	GOOD (1) Functioning Properly	FAIR (2) Functioning at Risk	POOR (3) Impaired
Fire Regime Condition	Fire Regime Condition Class (FRCC) 1 - A predominate percentage of the watershed is within the natural (historical) range of variability ("reference fire regime") of vegetation characteristics; fuel composition; fire frequency, severity and pattern; and other associated disturbances. The vegetative species and cover types are well adapted to the fire regime and offer good protection to soil and water resources.	Fire Regime Condition Class (FRCC) 2 - A predominate percentage of the watershed has a moderate departure from the reference fire regime of vegetation characteristics; fuel composition; fire frequency, severity and pattern; and other associated disturbances. The vegetative species and cover types are somewhat affected by the abnormal fire regime and results in less protection to soil and water resources when fire occurs.	Fire Regime Condition Class (FRCC) 3 - A predominate percentage of the watershed has a high departure from the reference fire regime of vegetation characteristics; fuel composition; fire frequency, severity and pattern; and other associated disturbances. The vegetative species and cover types are affected by the fire regime and results in periods of fuel accumulation with infrequent intense fires with high severity that are more likely to produce vegetation mortality, loss of soil organic matter, and poor protection to soil and water resources.
Fire Regime Condition OR Wildfire Effects			
Attributes	GOOD (1) Functioning Properly	FAIR (2) Functioning at Risk	POOR (3) Impaired
Wildfire Effects	Following a significant wildfire, impacts are such that soil and ground cover conditions in the burned area are expected to recover within 1-2 years to levels that provide watershed protection appropriate for the location and ecotype.	Following a significant wildfire, soil and ground cover conditions are causing some post-fire runoff and erosion concerns but are not sufficient to jeopardize long-term watershed condition integrity. This condition may persist for 2 to 5 years after a wildfire.	Following a significant wildfire, soil and ground cover conditions are causing considerable post-fire runoff, erosion and flooding threats to watershed condition integrity lasting for more than 5 years.

Additional Guidance:

1. The Fire Effects and Regime Condition Indicator is unique in that it is an EITHER OR proposition in which either Fire Regime Condition or Wildfire Effects is rated. In most cases, the Fire Regime attribute will be rated. However, following a significant wildfire, the Wildfire Effects attribute is rated and the Fire Regime attribute is rated N/A (not applicable). This is the only indicator that operates in this manner.
2. Wildfire Effects: Watersheds experiencing significant wildfire (one that effectively changes the FRCC) will be rated using the Wildfire Effects attribute until the watershed fully recovers from any adverse wildfire effects (i.e., a rating of 2 or 3) and during this time the Fire Regime Condition Class attribute will be rated as Not Applicable (N/A). Forests should switch to this attribute if more than 50% of the watershed is affected by a significant wildfire. If less than 50% of the watershed is affected by a significant wildfire, switching to this attribute may still be appropriate and should be assessed by the Forest on a case-by-case basis. In the wake of a significant wildfire, only the Wildfire Effect attribute correctly characterizes the state of the watershed with respect to watershed condition. For example, following severe wildfire, a watershed previously in FRCC 3 (Poor) reverts to FRCC 1 (Good) because it has been returned to its natural reference condition and the Wildfire Effects attribute will now be rated as 3 (Poor). Averaging the two attributes results in an incorrect characterization of watershed condition. To avoid this, watershed condition will be rated based on the Wildfire Effects attribute during the entire watershed recover period.
3. Fire Regime Condition: In watersheds that clearly have more than one FRCC, use the formula below to determine the Category.

Methodology:

1. Determine for each 6th HUC watershed the percentage of the total watershed area within each of the Fire Regime Condition Classes (FRCC1, FRCC2, and FRCC3). Use GIS overlays if possible.
2. FRCC1 is assigned a category score of 1; FRCC2 is assigned a category score of 2, and FRCC3 is assigned a category score of 3.
3. Calculate the weighted average fire regime condition class ($FRCC_{wtavg}$) using the formula below:

$$FRCC_{wtavg} = \frac{(FRCC1 * 1) + (FRCC2 * 2) + (FRCC3 * 3)}{FRCC1 + FRCC2 + FRCC3}$$

where:

FRCC1 = acres of watershed within Fire Regime Condition Class
1
FRCC2 = acres of watershed within Fire Regime Condition Class
2

FRCC3 = acres of watershed within Fire Regime Condition Class
3

Categorize fire regime condition using the following calculated weighted average fire regime condition class ranges:

Category 1 1.0 to 1.66
Category 2 1.67 to 2.33
Category 3 2.33 to 3.0

4. Fire Regime Condition: While the use of national FRCC map products is encouraged, Forests may refine FRCC as appropriate to fit their local situations.
 - a. Example 1: Forests in the Southern Region may wish to use the “Fire Frequency-Severity Condition Class” and omit the “Succession Class Condition Class” in their determination of Watershed Condition ratings since this seems to be more appropriate for these ecosystems.
 - b. Example 2: Forests in the Southwest, may wish to use INFORMS data instead of the national LANDFIRE data since it provides a better estimate of local conditions. Any of these modifications should be documented and a coordination role by the Regional Offices is suggested.

Definitions:

Fire Regime Condition Class (FRCC) - Fire regime condition classes measure the degree of departure from reference conditions, possibly resulting in changes to key ecosystem components, such as vegetation characteristics (species composition, structural stage, stand age, canopy closure, and mosaic pattern); fuel composition; fire frequency, severity, and pattern; and other associated disturbances, such as insect and disease mortality, grazing, and drought. Possible causes of this departure include (but are not limited to) fire suppression, timber harvesting, livestock grazing, introduction and establishment of exotic plant species, and introduced insects and disease. FRCC is strictly a measure of ecological trends.

The three fire regime condition classes are categorized using the following criteria: FRCC 1 represents ecosystems with low (<33 percent) departure and that are still within the estimated historical range of variability during a specifically defined reference period; FRCC 2 indicates ecosystems with moderate (33 to 66 percent) departure; and FRCC 3 indicates ecosystems with high (>66 percent) departure from reference conditions. As described below, departure is based on a central tendency (or mean) metric and represents a composite estimate of the reference condition vegetation characteristics; fuel composition; fire frequency, severity, and pattern; and other associated natural disturbances. Low departure includes a range of plus or minus 33 percent deviation from the central tendency.

Characteristic vegetation and fuel conditions are considered to be those that occurred within the natural fire regime, such as those found in areas categorized as FRCC 1 (low departure). Uncharacteristic conditions are considered to be those that did not

occur within the natural regime, such as areas that are often categorized as FRCC 2 and 3 (moderate to high departure). These include (but are not limited to): invasive species (weeds and insects), diseases, “high graded” forest composition and structure (in which, for example, large fire-tolerant trees have been removed and small fire-intolerant trees have been left within a frequent surface fire regime), or overgrazing by domestic livestock that adversely impacts native grasslands or promotes unnatural levels of soil erosion.

Watershed Recovery Period - The period of time, in years, that is required for the burned area to develop vegetation and infiltration conditions sufficient to reduce runoff and erosion potential to essentially pre-disturbance conditions. This is a best estimate of natural regeneration, soil stabilization, and hydrophobicity reduction, supplemented by any treatments prescribed (USDA FS 2009).

Rationale for Indicator:

Watershed condition to a large extent is controlled by the composition and density of vegetative cover and the amount of bare soil resulting from anthropogenic or natural disturbances that affect the watershed (Neary et al. 2005). Fire operates principally through alteration of vegetation and soil properties to alter hydrologic and geomorphic processes. The effects are generally increased soil water and overland flow which result in accelerated erosion by a variety of surface and mass movement processes. The magnitude of the effects on an ecosystem depends to a large degree on the frequency and intensity of fire and the sensitivity of the ecosystem to disturbance (Swanson 1981). Fire regime and geomorphic sensitivity may be used to characterize and contrast the geomorphic consequences of fire in different ecosystems. For example, frequent, intense fire in highly erosive landscapes, such as steep-land chaparral in southern California, is an extremely important component of some geomorphic systems. The effects of fire are progressively less significant in ecosystems systems in which fire is less frequent and/or less intense. Fire regime condition class, which is a measure of vegetation departure from reference condition, corresponds well to evaluating these kinds of potential impacts to watershed condition. Wildfires have the potential to exert a tremendous influence on the hydrologic conditions of watersheds in many forest ecosystems depending on the fire’s severity, duration, and frequency. Wildfire is the single forest disturbance that has the greatest potential to change watershed condition (DeBano et al. 1998). An extensive, high severity wildfire can destroy the vegetation and litter layer in a watershed and detrimentally impact alter physical properties of the soil including infiltration and percolation capacities. These cumulative fire effects can change the watershed condition from good to poor, resulting in unacceptable-increases to overland flow, erosion, and soil loss (Neary et al. 2005).

Indicator References:

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9. Forest Cover Condition

Purpose: This indicator addresses the potential for altered hydrologic and sediment regimes due to the loss of forest cover on forest lands (lands being managed as natural or semi-natural forest ecosystems).

CONDITION RATING RULE SET

9. Forest Cover Condition Indicator	The amount of NFS forest land in the watershed that is not supporting forest cover is minor.	The amount of NFS forest land in the watershed that is not supporting forest cover is moderate.	The amount of NFS forest land in the watershed that is not supporting forest cover is high.
Attributes	GOOD (1) Functioning Properly	FAIR (2) Functioning at Risk	POOR (3) Impaired
Forest Cover	Less than 5% of NFS land in the watershed contains cut-over, denuded, or deforested forest land where appropriate forest cover should be reestablished or restored in order to achieve the desired conditions or other applicable Forest Plan direction for NFS lands.	5% to 15% of NFS land in the watershed contains cut-over, denuded, or deforested forest land where appropriate forest cover should be reestablished or restored in order to achieve the desired conditions or other applicable Forest Plan direction for NFS lands.	Greater than 15% of NFS land in the watershed contains cut-over, denuded, or deforested forest land where appropriate forest cover should be reestablished or restored in order to achieve the desired conditions or other applicable Forest plan direction for NFS lands.

Additional Guidance:

1. The focus of this indicator is on the presence/absence of forest cover on NFS lands in consideration of National Forest Management Act (NFMA) requirements. Because non-NFS lands do not have this Federal legal standard for forest cover, those private and other ownerships are not included in rating the watershed for this indicator.
2. This indicator may be rated “not applicable” if forest cover (as defined below) is absent in the watershed. If Forest Cover is rated not applicable, rangeland condition must be rated. In effect, a watershed can be characterized as having forest cover, rangelands, or both. In many watersheds, both indicators will be rated. Note that lands that meet the definition of Forest Land will also normally have a rangeland component to the understory. This is especially so where the tree cover is relatively sparse (normally less than 60% canopy cover) with the amount of rangeland vegetation increasing as tree canopy cover decreases. In these instances, both indicators shall be evaluated and rated.
3. The most accurate and rapid assessment will be produced if the FACTS database reflects current conditions regarding loss of forest cover and planned or subsequent reforestation activities. Use sources such as RAVG (Rapid Assessment of Vegetation Condition After Wildfire) to update FACTS until field exams can be conducted. Apply FACTS business rules.

4. Methodology:

- a. Calculate percent for each 6th HUC watershed using the formula below:

$$\frac{A_D}{A_T} (100)$$

where:

A_D = area (in acres) of NFS forest land within the watershed that is not providing forest cover. This is NFS land that meets all three of the following criteria:

- i. is being managed as forest land (a land-use determination defined by the LMP),
- ii. has been cut over, denuded, or lost forest cover from any human or natural disturbance, and
- iii. where forest cover has not yet been reestablished. See the definition of *Forest Cover* below.

A_T = total area (in acres) of NFS forest land within the watershed. Obtain from best source such as NRM-NRIS, legacy databases, other assessments, remote sensing, or GIS sources.

- b. Using the percentage from step a, categorize each watershed's forest cover condition into either Category 1, 2, or 3.

Definitions:

Forest Cover - Areas where trees provide 10% or greater canopy cover and are part of the dominant (uppermost) vegetation layer, including areas that have been planted to produce woody crops. For the purposes of watershed condition assessment, lands that do not yet provide 10% tree canopy cover will be considered as meeting the definition of forest cover if the areas have been certified and recorded in FACTS as having been regenerated to appropriate forest cover (whether through natural or artificial regeneration) as per the local unit's Forest Plan standards and guidelines. "Appropriate forest cover" may be defined in one or more of the following Forest Plan components (desired conditions, standards, guidelines, management area prescriptions and allocation map, map of lands suitable for timber production, or other direction). The following FACTS codes are applicable (these are used to generate the Reforestation Needs Report): Harvest Codes 4101, 4102, 4110-17, 4131-34, 4143, 4147, 4150-52, 4160, 4162, 4175-77, 4183, and 4194; Causal Agent: 4250, 4260, 4265, 4270, 4280, and 4290.

Forest Land: - Land at least 10 percent occupied by forest trees or formerly having had such tree cover and not currently developed for nonforest use. Lands

developed for nonforest use include areas for crops, improved pasture, residential, or administrative areas, improved roads of any width, and adjoining road clearing and power line clearing of any width (FSM 1905). NOTE: Designated wilderness, roadless areas, and unproductive forest land that meet the above definition are classified as forest land.

Rationale for Indicator:

This is a foundational indicator of whether forest ecosystems are being sustained or lost over time (“Maintain forests as forests.”). The ability of forests to regulate water flows and maintain quality supplies is affected by the condition of the forest and the occurrence of disturbances that change the structure, composition, and pattern of forest vegetation. Forest cover is a primary terrestrial ecosystem component important to watershed condition. Trees provide many water- and soil-related ecosystem services such as intercepting precipitation and protecting soil, regulating snowmelt, and stabilizing steep slopes. Extensive loss of forest cover due to severe wildfires, widespread insect and disease epidemics, timber harvest, weather events, and long-term drought affects runoff, erosion, sediment supply, bank stability, large woody debris retention, and stream temperature relationships (MacDonald et al. 1991, Meehan 1991, Reid 1993). Many of the impacts from these and similar disturbances decrease after the initial disturbance but may remain above natural levels for many years (Platts and Megahan 1975). Carefully designed and executed management actions can both restore vegetative cover and improve watershed condition.

Section 4 (Reforestation) of the Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974, as amended by the [National Forest Management Act \(NFMA\) of 1976](#) (16 U.S.C. 1601(d)(1) establishes the policy of the Congress that all forested lands in the National Forest System be maintained in appropriate forest cover with species of trees, degree of stocking, rate of growth, and conditions of stand designed to secure the maximum benefits of multiple use sustained yield management in accordance with land management plans.

Regarding private lands, note that some states (such as California) have forest regulations requiring reestablishment or maintenance of forest cover after timber harvest.

Indicator References:

MacDonald, L.H., A. Smart and R.C. Wissmar. 1991. Monitoring guidelines to evaluate effects of forestry activities on streams in the Pacific Northwest and Alaska. EPA/910/9-91-001, U.S. Environmental Protection Agency Region 10, Seattle, WA. 166 pp.

- Meehan, W.R., editor. 1991. Influences of forest and rangeland management on salmonid fishes and their habitat. American Fisheries Society, Special Publication 19, Bethesda, Maryland.
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- Reid, L.M. 1993. Research and cumulative watershed effects. Gen. Tech. Rep. PSW-GTR-141. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 118 p.
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10. Rangeland Vegetation

Purpose: This indicator addresses impacts to soil and water relative to the vegetative health of rangelands.

CONDITION RATING RULE SET

10. Rangeland Vegetation Condition Indicator	Rangelands reflect native or desired non-native plant composition and cover at near natural levels as defined by the site potential.	Rangelands reflect native or desired non-native plant composition and cover with slight to moderate deviation compared to natural levels as defined by the site potential.	Rangelands reflect native or desired non-native plant composition and cover and are greatly reduced or unacceptable altered compared to natural levels as defined by the site potential.
Attributes	GOOD (1) Functioning Properly	FAIR (2) Functioning at Risk	POOR (3) Impaired
Rangeland Vegetation Condition	Vegetation contributes to soil condition, nutrient cycling, and hydrologic regimes appropriate to the site. Functional/structural groups, number of species, and plant mortality and decadence closely match that expected for the site; average annual plant production equals or exceeds 70% of production potential; litter amount is approximately what is expected for the site potential and weather; the reproductive capacity of native or naturalized perennial plants to produce seeds or vegetative tillers is sustainable over the long-term; and, introduced plant species are being managed to facilitate long-term replacement by site-adapted native species.	Functional/structural groups and number of species are slightly to moderately reduced; some dead and/or decadent plants are present above what would be expected for the site; average annual plant production is 40–69% of production potential; litter amount is moderately less than would be expected relative to site potential and weather; the reproductive capacity of perennial native or naturalized plants to produce seeds or vegetative tillers is somewhat reduced but is still sustainable over the long-term; and, introduced plant species are being managed to facilitate long-term replacement by site-adapted native species or to ensure adequate ground cover to protect the soil.	Functional/structural groups and number of species are moderately to greatly reduced or altered relative to site potential; dead and/or decadent plants are significantly more common than would be expected for the site; average annual plant production is less than 40% of production potential; litter is largely absent or is sparse and disconnected relative to site potential and weather; the reproductive capacity of native or naturalized perennial plants to produce seeds or vegetative tillers (native or seeded) is severely reduced relative to site potentials; and introduced plant species are dominant and are not effective in protecting the site and soil.

Additional Guidance:

1. Rangelands are rated relative to biotic integrity. Use guidance and definitions found in the publication, “Interpreting Indicators of Rangeland Health” (Pellant et al. 2005) to assist with this evaluation. Because of the close interrelationship between soils, hydrology, and vegetation condition, rangeland ecologists, hydrologists, and soil scientists are encouraged to work together to make this evaluation. Rangeland soil/site stability and hydrologic

function are rated in the Soils Condition indicator. Invasive species are rated in the Terrestrial Invasive Species Condition Indicator.

2. If Forest Plan rangeland direction exists for ecological condition (functional structural groups, plant mortality/decadence, annual production, litter amounts, reproductive capacity, or similar attributes), use the local thresholds derived from Forest Plan standards and guidelines to determine the appropriate rating.
3. This indicator may be rated “not applicable” if rangelands (as defined below) is absent in the watershed. If Rangeland is rated not applicable, forest cover condition must be rated. In effect, a watershed can be characterized as having forest cover, rangelands, or both. In many watersheds, both indicators will be rated. Decisions to exclude rangelands if rangelands are not present may be made on an individual watershed basis, but in many cases, the decision will apply to an entire National Forest. Coordination with the Regional Oversight Team is recommended.

Definitions:

Biotic Integrity (Integrity of the Biotic Community) - Capacity of a site to support characteristic functional and structural communities in the context of normal variability, to resist loss of this function and structure due to a disturbance, and to recover following such disturbance (Pellant et al. 2005).

Rangeland Land on which the indigenous vegetation (climax or natural potential) is predominantly grasses, grass-like plants, forbs, or shrubs and is managed as a natural ecosystem. If plants are introduced, they are managed similarly. Rangelands include natural grasslands, savannas, shrub lands, many deserts, tundra, alpine communities, marshes, and wet meadows (Society of Range Management 1999). The authors also include oak and pinyon-juniper woodlands in this definition (Pellant et al. 2005). In this assessment, we will rate the condition of marshes under the Riparian/Wetland Vegetation indicator.

Properly Functioning - Rangelands that are functioning properly relative to the ecological site description and/or ecological reference area given the normal range of variability associated with the site and climate.

Functioning at Risk - Rangelands that have a reversible loss in productive capability and increased vulnerability to irreversible degradation based upon an evaluation of current conditions of the soil and ecological processes (National Research Council 1994).

Impaired - Rangelands on which degradation has resulted in the loss of ecological processes which function properly and the capacity to provide values and commodities to a degree that external inputs are required to restore the health of the land (National Research Council 1994).

Rationale for Indicator:

Rangeland health is a function of (1) soil/site stability –the capacity of the site to limit redistribution and loss of soil resources (including nutrients and organic matter) by wind and water; (2) hydrologic function – the capacity of the site to capture, store, and safely release water from rainfall, runoff, and snowmelt and to recover following disturbance; and (3) the integrity of the biotic community – the capacity of the site to support ecological processes within the normal range of variability expected for the site and to recover following disturbance (Pellant et al. 2005). Improper management can decrease ground cover and reduce species diversity, composition and/or cover. Improper management has been shown to be capable of resulting in diminished watershed functionality through soil compaction, which may increase overland flow and lead to incised channels and bank erosion (Kaufman and Kreuger 1984, Bohn and Buckhouse 1986, Platts 1991). Conversely, proper management can lessen adverse effects (Clary and Webster 1989). In summary, properly functioning rangeland vegetative communities provide for conditions that sustain soil stability, hydrologic function, and biotic diversity.

Indicator References:

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11. Terrestrial Invasive Species Condition

Purpose: This indicator addresses potential impacts to soil, vegetation, and water resources due to terrestrial invasive species (including vertebrates, invertebrates, and plants).

CONDITION RATING RULE SET

11. Terrestrial Invasive Species Condition Indicator	Few, or no, populations of terrestrial invasive species infest the watershed that could necessitate removal treatments that would affect soil and water resources.	Populations of terrestrial invasive species are established within the watershed and/or the rate of expansion and/or potential for impact on watershed resources is moderate.	Terrestrial invasive species populations infest significant portions of the watershed, are expanding their range, and there is documentation of widespread impacts to watershed resources.
Attributes	GOOD (1) Functioning Properly	FAIR (2) Functioning at Risk	POOR (3) Impaired
Terrestrial Invasive Species Condition Indicator	Few (<10%), or no, populations of terrestrial invasive species infest the watershed that could necessitate removal treatments to protect, soil, native vegetation, or other water resources. Those that occur are small in extent and scattered in nature. The rate of spread and/or potential for impact on watershed resources is minimal or unlikely. Management intervention may be necessary to prevent increased risk of spread or invasion. Integrated management treatments may temporarily negatively impact soil, native vegetation, and other water resources but the scale and scope would be minor.	Populations of terrestrial invasive species are established within (10%-25%) the watershed and/or the rate of spread and/or potential for impact on soil, vegetation, or other water resources is moderate. Integrated treatments affect 10-25% of the watershed, and must be ongoing just to keep the invasive species in check. Management intervention will be required to prevent increased level of risk.	Populations of terrestrial invasive species infest significant portions (>25%) of the watershed, may be expanding their range, and there is documentation of widespread impacts to soil, native vegetation, or other water resources. Treatments for containment affect over 25% of the watershed, and management adjustments and/or treatments need to be ongoing just to keep the invasive species in check. Management intervention is necessary to alleviate significant resource damage and increased degradation of watershed condition.

Additional Guidance:

1. This indicator applies only to terrestrial vertebrates, invertebrates, and plants that may have an adverse impact to soil and water resources. Aquatic invasive species are considered under Aquatic Biota Condition. Invasive insects and pathogens (including native forest insect pests and diseases) are covered under the Forest Health indicator.
2. Infestation Extent: Infestation Extent is usually evaluated through risk assessments and other inventory/evaluation procedures at either the species-

level, site-level, or project-level. For example the extent of the terrestrial invasive species infestation on an individual species-level may indicate that the watershed condition rating is “good”, yet when viewed within the context of all the documented terrestrial invasive species infesting the entire watershed, the overall condition rating may be considered “poor”.

3. Integrated management treatments against terrestrial invasive species may temporarily negatively impact soil, native vegetation, and other watershed resources; requiring a restoration component to the project plan.

Definitions:

Native Species - With respect to a particular ecosystem, a species that historically occurred in that ecosystem.

Terrestrial Invasive Species - A terrestrial invasive species (including vertebrates, invertebrates, pathogens, and plants) is a species not native to the ecosystem location under consideration, and its introduction causes or is likely to cause economic or environmental harm, or harm to human health. The lack of natural ecological controls (which typically kept these exotic species regulated in their native home) allows these exotic species to significantly impact (cause harm) the areas they invade. Terrestrial invasive species refers to harmful exotic species that are found or occur on the land surface rather than in aquatic environments. There are many exotic plant and animal species occupying terrestrial habitats, but they are not necessarily invasive (harmful) and typically cause little to no economic or environmental damage, and do not out-compete or displace native plants or animals.

Rationale for Indicator:

Environmental harm to watershed conditions may occur from invasive species when they produce significant changes in ecological processes, sometimes across broad geographical area, which result in conditions that native animal and plant communities cannot tolerate. Some invasive species can significantly alter effective ground cover, erosion rates and nutrient cycling, change the frequency and intensity of wildfires, or alter the hydrology of rivers, streams, lakes and wetlands (Mack et al. 2000). For example, for cheatgrass the link to soil and hydrologic processes is through a chain of logic that recognizes that cheatgrass may seasonally provide adequate cover for watershed protection, but because cheatgrass is an annual with a sparse growth habit, and because it dies off early in the summer and leaves little to no vegetative soil protection, and because its production depends on the weather, in very dry years production can be so low there is little soil protection. Consequently, its overall ability to protect the soil is minimal (and is well outside of the native site potential). Also, since disturbance of the soil is the main reason cheatgrass spreads, this is closely associated with an undesirable condition from a soil and water perspective. Cheatgrass in the Great Basin region has been shown to decrease the interval between the occurrences of

wildfires from once every 70 to 100 years to every 3 to 5 years because it forms dense stands of fine fuel annually. This decrease in interval between wildfires causes more severe soil erosion and dramatically alters desirable native plant communities (Knapp 1996; Pimentel et al. 2000). Similarly, tamarisk (salt cedar) in the southwest, disrupts the structure and stability of North American native riparian plant communities by out competing and replacing native plant species, increasing soil salinity, monopolizing limited sources of moisture, and increasing the frequency, intensity and effect of fires and floods. Tamarisk has taken over large sections of riparian ecosystems in the Western United States that were once home to native cottonwoods and willows (Christensen 1962; Stromberg 1998). In addition, infestations of terrestrial invasive vertebrate species such as wild (feral) pigs, cause widespread soil erosion, harbor infectious diseases, damage native vegetation, and are aggressive predators on native vertebrate and invertebrate wildlife (USDA-APHIS 1999).

Indicator References:

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12. Forest Health Condition

Purpose: This indicator addresses forest mortality impacts to hydrologic and soil function due to major invasive and native forest pest insect and disease outbreaks and air pollution.

CONDITION RATING RULE SET

12. Forest Health Condition Indicator	A small amount of the forested land in the watershed is anticipated to or is experiencing tree mortality from insects and disease and air pollution.	A moderate amount of the forested land in the watershed is anticipated to or is experiencing tree mortality from insects and disease and air pollution.	A large amount of the forested land in the watershed is anticipated to or is experiencing tree mortality from insects and disease and pollution.
Attributes	GOOD (1) Functioning Properly	FAIR (2) Functioning at Risk	POOR (3) Impaired
Insects & Disease	Less than 5 percent of the forested land in the watershed is at imminent risk of abnormally high levels of tree mortality (a level of 25 percent in a stand is deemed to represent an uncommon, rather extraordinarily high amount of mortality) due to insects and disease.	5% to 20 % of the forested land in the watershed is at imminent risk of abnormally high levels of tree mortality (a level of 25 percent is deemed to represent an uncommon, rather extraordinarily high amount of mortality) due to insects and disease.	More than 20% of the forested land in the watershed is at imminent risk of abnormally high levels of tree mortality (a level of 25 percent is deemed to represent an uncommon, rather extraordinarily high amount of mortality) due to insects and disease.
Ozone	Ozone causes a decrease in biomass growth in fewer than 20% of the years evaluated.	Ozone causes a decrease in biomass growth in 20 - 40% of the years evaluated..	Ozone causes a decrease in biomass growth in more than 40% of the years evaluated; and/or the watershed is within an area exceeding the National Ambient Air Quality Standards (NAAQS) for ground-level ozone.

Additional Guidance:

1. Insects and Disease: Once outbreaks occur, there is very little that can be done to halt or slow the spread thus the presence of imminent outbreaks will be treated as if the undesirable condition already exists.
2. Insects & Disease: Forests will use the 2006 National Insect and Disease Risk Map (NIDRM) (Krist et al. 2007) as a beginning point for evaluating existing and potential future conditions. Areas at risk on NIDRM represent locations at which current stand or ecological conditions indicate that there is potential for Insect and Disease activity both in the near and long term if remediation is not undertaken. NIDRM is an integration of 188 individual risk models constructed within a common framework that is adaptable to regional variations in current and future forest health. The 2006 risk assessment introduced a consistent, repeatable, transparent process, through which interactive spatial and temporal risk assessments can be conducted at various

scales. Primary contributors to the risk of mortality included mountain pine beetle, oak decline on red oaks, southern pine beetle, root diseases, gypsy moth, pine engraver beetle, fir engraver beetle, Douglas-fir beetle, spruce beetle, hardwood decline, and western pine beetle. The threshold for mapping risk is: the expectation that, without remediation, 25 percent or more of the standing live basal area on trees greater than 1 inch in diameter will die over the next 15 years due to insects and diseases. Krist et al. (2007) mapped watersheds most at risk at the 4th code HUC (see Figure 11 in the parent publication) showing the percentage of forested lands at risk as 4 categories: 0 – 5%; 5 – 20%, 20 – 40%; and 40-86%. The lowest risk category (0 – 5%) is assigned as Condition Rating 1, the category 5-20% is assigned as Condition Rating 2, and >20% is assigned as Condition Rating 3. The same categories of mortality are used to assess current conditions.

3. Insects & Disease: All 6th HUC watersheds within mapped 4th level HUC watersheds will be assigned the same risk category as the 4th HUC watershed unless the Forest has better data available locally, from inventories or other assessments. Note: Finer scale maps at the 6th level HUCs have been constructed in GIS by Ted Geier using the original data. These finer resolution 6th level HUC maps will be made available to Forests for use during the classification process.
4. Insect and Disease Detection Surveys: Aerial sketch mapping is the primary data-collection method for this annual dataset. Observers code polygon data with damage agent, damage type and a range of other possible attributes including host, severity and approximate dead trees per acre. Data describing the condition within the polygon can be continuous or discontinuous and serves mostly as a snapshot in time of current and past activity. These data are subjective in nature, but may add valuable information for watershed assessment, particularly in areas where large mortality or defoliation events have occurred. Information about USFS Insect and Disease Detection Surveys are available from <http://www.fs.fed.us/foresthealth/technology/adsm.shtml>
5. Ozone: Assessments should use data from a nearby ambient ozone monitor or the national GIS coverage based on the ozone monitoring network. The attribute rating is determined by the percentage of years modeling shows that biomass growth is reduced by 10% or more. Contact the local Air Specialist or Forest Health Specialist for assistance with this analysis.
6. Ozone: Any years where the soil moisture is low (i.e., drought), the watershed(s) should be classified as “Good” because it is unlikely the ozone exposures contributed to any biomass reductions.
7. Ozone: The Forests are encouraged to obtain ozone bioindicator data from the National Forest Health Monitoring program and/or by conducting field surveys if a watershed is consistently being rated as poor. The presence of ozone symptoms on ozone sensitive species indicates a physiological response to the chronic and/or acute ozone exposure.

Rationale for Indicator:

Healthy forests are an important component of watershed health. Two primary influences on forest health are insects and disease and air pollution. Insects and disease along with fire are important regulators of forest change. Insects and disease can negatively affect resource values and ecosystem functions including reducing the ability of forest canopies to intercept snow and prevent excessive runoff. Recent increases in forest area affected by insect outbreaks and possible links to fire suppression have created a resurgence of interest in their possible effects to water quantity, quality, and risks. Relatively few studies have examined the hydrologic response of forests to insects and disease, especially at long time scales or in large watersheds (WSTB, 2008). While much remains to be understood, the effects of insects and disease on watershed condition can be extrapolated from general principles derived from studies of timber harvest and fire (MacDonald and Stednick, 2003). Air pollution effects are addressed by the impact of ground-level ozone on forest vegetation. Ozone can cause reductions in photosynthesis which can decrease the amount of root growth, tree height, and crown width making the weakened trees more susceptible to insect attacks (Lefohn and Runeckles, 1987; Lefohn, 1992).

Indicator References:

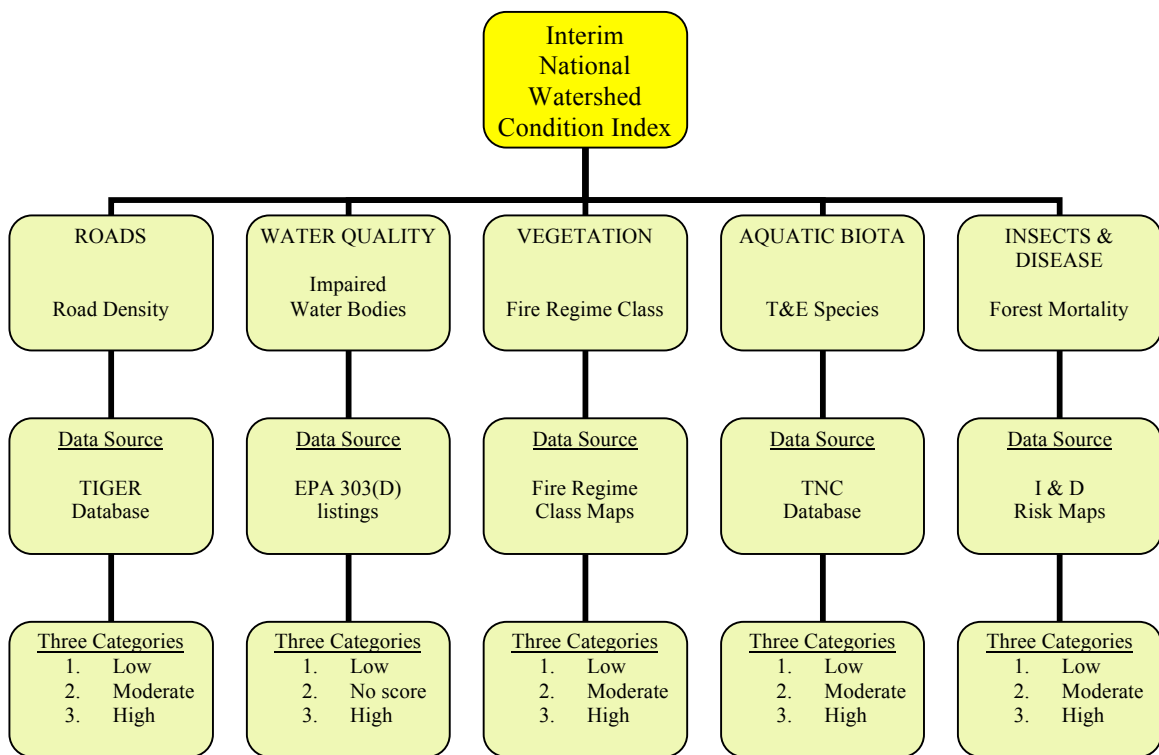
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<http://www.fs.fed.us/foresthealth/technology/nidrm.shtml>
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Appendix B: Interim National Watershed Condition Index

Developed by John Potyondy & Ted Geier

Objective: Provide a watershed condition index and map for use at the national scale based on five major NFS strategic priorities (fire, T&E species, roads, water quality, and insects and disease). The index uses nationally consistent GIS data layers and can be used to inform decisions about watershed restoration priorities at the national level.

- Forest Service watershed improvement direction emphasizes work in focus watersheds to address water quality limited streams, T&E species, support activities to improve forest health (reduce insect and disease and fire risk), and to restore watersheds adversely impacted by management activities (frequently roads).
- These priorities reflect national Forest Service strategic direction, management focus, and priorities and have a significant influence and connection to the soil and hydrologic function of watersheds.
- A simple 5-indicator, 3 class watershed integrity model is used for a coarse-filter assessment of watershed condition at a national scale. The 5 indicators were evaluated using the FS Ecosystem Management Decision Support (EMDS) system and results are displayed as color-coded maps.
- Each of the 5 indicators was categorized as low, moderate, or high integrity corresponding to the three FS Watershed Condition Classes (FSM 2521). Low implies proper function (Class 1), moderate implies functioning at risk (Class 2), and high implies impaired function (Class 3).
- The 5 indicators were overlaid in GIS and composite scores computed to yield a FS Watershed Condition Class for each watershed (Class 1, 2, or 3).
- Maps of individual factor ratings and whole watershed composite ratings were generated using a simple low, moderate, high (red, yellow, green) coarse-filter display. The map provides a first approximation of relative watershed condition across all NFS lands at the 5th-level scale (40,000 to 250,000 acres).
- The displays provide managers with consistent data-driven information that can be used to develop watershed improvement priorities at the national scale.
- During FY 2011, this approach will be replaced by the Watershed Condition Framework classification process to be conducted by National Forest resource specialists who will validate these results using local data and information. These local assessments will focus on existing watershed condition and will be conducted at the 6th-level HUCs scale so that improvement to watershed condition from FS watershed restoration activities can be evaluated. Classifications at this scale will replace conditions classes generated from GIS data.
- This Interim Watershed Condition Index is based on nationally consistent GIS data, is conceptually simple, and provides a transparent process for determining watershed condition classes at a coarse-filter scale illustrated below.



Additional Details:

The indicators tracked by the Interim Watershed Condition Index are:

1. **Roads** where the density of roads in a watershed is a surrogate indicator of the amount of land disturbance within a watershed.
2. **Water Quality** where the presence of impaired water bodies not meeting State water quality standards is a measure of the degree to which watersheds are in an unacceptable condition.
3. **Vegetation** where fire regime condition class indicates departure from desired vegetation condition and the risk of losing ecosystem components to catastrophic fires.
4. **Aquatic Biota** where the presence of threatened and endangered aquatic species is a surrogate for the biological integrity of aquatic systems within a watershed.
5. **Insects and Disease** where predicted forest mortality is an indicator of potential watershed condition.

Determining Category Breaks:

- **Roads:** Computed road density for all NFS watersheds and plot as a cumulative frequency curve. The HIGH road risk class was arbitrarily assigned to the upper 25% of the distribution and LOW road risk class to the upper 25% of the distribution. Everything between these extremes was placed in the MODERATE class.

- **Water Quality:** Watersheds having at least 1 water quality limited water body were assigned a HIGH risk category. Watersheds having no water quality limited segments were assigned a LOW risk category. There is no MODERATE category for the indicator.
- **Vegetation:** Fire Regime Condition Class 1 was assigned a LOW risk category. Fire Regime Condition Class 2 was assigned a MODERATE risk category. Fire Regime Condition Class 3 was assigned a HIGH risk category.
- **Aquatic Biota:** Watersheds with no aquatic T&E species were assigned a LOW risk category. Watersheds with 1-5 aquatic T&E species were assigned a MODERATE risk category. Watersheds with 6-17 aquatic T&E species were assigned a LOW risk category.
- **Insects & Disease:** Watersheds with 0-5% risk of forest mortality were assigned a LOW risk category. Watersheds with 5 - 20% risk were assigned a MODERATE risk category. Watersheds with >20% risk were assigned a HIGH risk category.

GIS data layers were obtained from the Rocky Mountain Research Station and are identical to those used by Brown and Froemke (2010) in their publication “Risk of Impaired Condition of Watersheds Containing National Forest Lands.” The interim assessment only includes five indicators thought to be most relevant to contemporary Forest Service management issues.